WILBUR L. CROSS LIBRARY
UNIVERSITY OF CONNECTICUT

f/TC/425/S14/A47/Appendix

Digitized by the Internet Archive
in 2013

http://archive.org/details/stlawrenceriverproj00unit

ST. LAWRENCE RIVER PROJECT

FINAL REPORT

1942

GENERAL DATA

UNIVERSITY OF CONNECTICUT
THE PROPERTY OF
LIBRARY

DOCUMENTS Room 8

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX A-2

S T. L A W R E N C E R I V E R

P R O J E C T

* * * * *

F I N A L R E P O R T

1 9 4 2

G E N E R A L D A T A

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office - Massena, New York

July , 1942

U. S. Army. Corps of Engineers

APPENDIX A-2

f
TC
425
S14
A47
Appendix

TABLE OF CONTENTS

PART ONE

OFFICIALS, EMPLOYEES, AND CONSULTANTS ASSOCIATED WITH THE INVESTIGATION OF THE ST. LAWRENCE RIVER PROJECT, OCTOBER, 1940 TO JUNE, 1942

OFFICIALS, EMPLOYEES, AND CONSULTANTS ASSOCIATED WITH THE INVESTIGATION OF THE ST. LAWRENCE RIVER PROJECT OCTOBER 1940 TO JUNE 1942

1. The following list gives the names of the principal people connected with the work between October 1940 and June 1942. The list is not intended to be exclusive but contains the names of the principal people whom it may be desirable to consult at some future date regarding details of the investigations. The names on the list are under five headings as follows:

   a. Members of the Advisory Committees.

   b. Department Employees of United States and Canada.

   c. Consulting Engineers.

   d. Employees of Hydro-Electric Power Commission of Ontario.

   e. Employees of St. Lawrence River District.

a. The Advisory Committees.

MEMBERS OF THE UNITED STATES ADVISORY COMMITTEE:

Berle, Hon. Adolph A.
Assistant Secretary of State
State Department
Washington, D. C.

Cruise, Gerald V., Executive Secretary
Power Authority of State of New York
State Office Building, 80 Centre Street
New York, N. Y.

Olds, Leland B., Chairman
United States-St. Lawrence Advisory Committee
Chairman, Federal Power Commission
Washington, D. C.

Robins, Major General Thomas M.
Office, Chief of Engineers
Washington, D. C.

MEMBERS OF THE CANADIAN ADVISORY COMMITTEE:

Hogg, Dr. Thomas H., Chairman
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Lefebvre, Dr. Olivier O., Vice-President
Quebec Streams Commission
Montreal, Quebec, Canada

Lindsay, Guy A.
Chairman, Canadian Temporary Great Lakes-St. Lawrence Advisory Board
Engineer in Charge, General Engineering Branch
Department of Transport
Ottawa, Ontario, Canada

Read, John E., Legal Advisor
Department of External Affairs
Ottawa, Ontario, Canada

b. Departmental Officials and Other Employees.

OFFICE, CHIEF OF ENGINEER MEN WHO HELPED:

Giroux, Carl H., Head Electrical Engineer (Electrical & Mechanical)
Office, Chief of Engineers
Washington, D. C.

Cave, William K. (Electrical)
Office, Chief of Engineers
Washington, D. C.

McAlpine, W. A., Chief Engineer (General Engineering)
Office, Chief of Engineers
Washington, D. C.

McFarland, Head Engineer (General Engineering)
Office, Chief of Engineers
Washington, D. C.

Middlebrooks, T. A. (Soil Mechanics)
Office, Chief of Engineers
Washington, D. C.

Shepard, E.R., Senior Physicist (Seismic)
Office, Chief of Engineers
Washington, D. C.

Steele, Byran W., Head Engineer (Dams & Concrete)
Office, Chief of Engineers
Washington, D. C.

OTHER UNITED STATES PEOPLE WHO HELPED:

Bennett, C. E., Electrical Engineer (Powerhouse)
Federal Power Commission
Washington, D. C.

Bostwick, T. J. Chief Electrical Engineer
Aluminum Company of America
Gulf Building
Pittsburgh, Pennsylvania

Bucher, Ralph D.
New York State Power Authority
State Office Building, 80 Centre Street
New York, N. Y.

Crane, C. C., Electrical Engineer
Federal Power Commission
Washington, D. C.

Davidson, Maurice P., Trustee
New York State Power Authority
State Office Building
80 Centre Street
New York, N. Y.

Freestone, Fred J.
New York State Power Authority
State Office Building
80 Centre Street
New York, N. Y.

Goetz, Charles M., Attorney
Federal Power Commission
Washington, D. C.

Grimm, C. I., Head Engineer (General Engineering)
North Pacific Division
500 Pittock Block
Portland, Oregon

Hough, Benjamin K. Jr., Senior Engineer (Soil Mechanics)
U.S. Engineer Office
Ithaca, New York

McWhorter, Roger B., Chief Engineer (Powerhouse)
Federal Power Commission
Washington, D. C.

Paige, Sidney, Senior Geologist (Geology)
North Atlantic Division
270 Broadway
New York, N. Y.

Parker, Colonel T. B., Chief Engineer (Powerhouse)
New York State Power Authority
Tennessee Valley Authority
Knoxville, Tennessee

Peden, C. W.
Aluminum Company of America
Massena, New York

Reed, George E.
New York State Power Authority
State Office Building
80 Centre Street
New York, N. Y.

OTHER UNITED STATES PEOPLE WHO HELPED: Cont'd

Schultz, S. E. (Transformers and Switching)
Bonneville Power Administration
1300 Union Avenue
Portland, Oregon

Whitzel, R. T., President
Aluminum Company of America
Massena, New York

Wuerpel, Charles E. (Concrete Aggregate)
Central Concrete Laboratory
320 Washington Street
Mount Vernon, New York

Youngman, William S., Junior General Counsel
Federal Power Commission
800 Pennsylvania Avenue, N.W.
Washington, D. C.

CANADIAN MEN WHO HELPED:

Atkinson, M. B., Asst. Suptg. Engineer
Welland Canal
St. Catherines, Ontario, Canada

Boulton, B. K. Operating Engineer
Beauharnois Light, Heat and Power Company
Beauharnois, Quebec, Canada

Hara, L. D., Officer in Charge
Ontario Canal
Cornwall, Ontario, Canada

Haverhill, H. W.
Montreal Heat, Light & Power Company
Montreal, Quebec, Canada

Hodgson, Earnest, Dominion Seismologist
Dominion Observatory
Ottawa, Ontario, Canada

Knapp, E. W.
Beauharnois Heat, Light & Power Company
Beauharnois, Quebec, Canada

Marr, Norman (Powerhouse)
Dominion Water & Power Bureau
Department of Mines & Resources
Ottawa, Ontario, Canada

CANADIAN MEN WHO HELPED: Cont'd

Moore, T. R. Department of Transport Ottawa, Ontario, Canada	(General Engineering)
Stratton, L. R. Department of Transport Cornwallis Hotel Cornwall, Ontario, Canada	(Contact with Canadian Officials)
St. Laurent, J.A.G. Department of Transport Ottawa, Ontario, Canada	(Dredging Plant)
West, C.W., Supt. Engineer Welland Canal Department of Transport St. Catherines, Ontario, Canada	
Wilson, A. E. (Miss) Geological Survey Department of Mines & Resources Ottawa, Ontario, Canada	(Seismology)

c. Consultants.

Carlberg, H.A. Harza Engineering Co. 205 W. Wacker Drive Chicago, Illinois	Consultant associated with Harza Engrg. Co.	Consultations on design and layout of power plant on St. Lawrence.
Clark, Dr. David G. Supt., Presbyterian Hospital New York, N. Y.	Expert Consultant on hospital design.	Consultations on hospital design.
Cothran, Frank 430 South Church St. Charlotte, North C.	Formerly Vice-President and Chief Engineer of Beauharnois Power & Light Company.	Consultations on design of structures and on river hydraulics.
Creager, William P. 9th Floor, Electric Bg. Buffalo, New York	Consultant Engineer	Consultations on design of structures and river hydraulics.
Crosby, Irving B. 6 Beacon Street Boston, Mass.	Consultant-Geologist	Consultations on foundation conditions for structures St. Lawrence River District
DeYoung, Isaac Sault St. Marie Michigan	Sr. Engr., U.S.E.D. (Retired)	Consultations on lock design.
Eldredge, Alburtus J. 3435 Broadway Place Columbus, Ohio	Expert om cableways.	Installation of cableway to Barnhart Island.
Field, William T. Flower Building Watertown, N. Y.	New York State Power Authority	Contact with New York Power Authority.
Floor, Erik Harza Engrg. Co. 205 W. Wacker Drive Chicago, Illinois	Chief Engr., Harza Engineering Company	Consultations on designand layout of power plant on St. Lawrence.
Gibbon, Harold Harza Engrg. Co. 205 W. Wacker Drive Chicago, Illinois	Consultant Engineer Harza Engrg. Company	Consultations on design and layout of power plant on St. Lawrence.
Gilboy, Dr. Glennon Lincoln, Mass.	Professor, Soil Mechanics, Consultant Engineer	Consultations on Soils mechanics this district.

Growdon, James P. 801 Gulf Building Pittsburgh, Pa.	Chief Engineer Aluminum Company Pittsburgh, Pa.	Consultations on design of structures and river hydraulics.
Gustafson, A. F. Cornell University Ithaca, N. Y.	Prof. Soils Mechanics Cornell University	Consultations on seeding dikes.
Hamilton, George W. 20 North Wacker Drive Chicago, Illinois	Consultant Engineer electrical Engrg.	Consultations on electrical engineering.
Harza, Leroy F. Harza Engrg. Co. 205 West Wacker Drive Chicago, Illinois	Pres. Harza Engrg. Co. - Contractor	Consultations on design and layout of power plant on St. Lawrence.
Hogan, John P. 142 Maiden Lane New York, N. Y.	Consultant Engineer N.Y. firm	Consultations on design of structures and river hydraulics.
Justin, Joel D. 1520 Locust Street Philadelphia, Pa.	Consultant Engineer	Consultations on design of structures and river hydraulics.
Neergaard, Charles F. 41 E. 42nd Street New York, N. Y.	Specialist in design of hospitals	Consultations on design and layout of proposed hospital.
Oliver, Ralph H. Harza Engineering Company Chicago, Illinois	Harza Engrg. Co. Consultant Engineer	Consultations on architecture of powerhouse.
Peacock, Frank E. Harza Engrg. Company Chicago, Illinois	Consultant Engineer Harza Engrg. Company	Consultations on powerhouse.
Sabin, L. C. Lake Carriers Assn. 905 Rockefeller Bldg. Cleveland, Ohio	Lake Carriers Assn.	Consultations on locks and canals.
Scharff, Maurice R. Consulting Engineer 285 Madison Avenue New York, N. Y.		

Sverdrup, Leif Jack Sverdrup & Parcel St. Louis, Missouri	Member, Technical Advisory Board, Am. Inst. of Steel Construction.	Consultations on bridge construction.
Wadsworth, Wm. J. Consulting Engineer Harza Engineering Co. 205 West Wacker Drive Chicago, Illinois	Consultant Engineer Harza Engineering Co.	Consultations on design and layout of power plant on St. Lawrence.

d. Employees of the Hydro-Electric Power Commission of Ontario.

Aberli, A.
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Black, S. W., Assistant Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Dibblee, John, Assistant Chief Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Frampton, A. H., Electrical Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Hendry, M. C., Assistant Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Holden, Otto, Chief Hydraulic Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Hull, A., Chief Electrical Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Simson, G. F.
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Wood, E. M., Electrical Engineer
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

e. <u>Employees of the St. Lawrence River District.</u>

Col. A. B. Jones	C.E., U.S. Army	St. Lawrence River Division.	District Engineer
Lt. Col. D. Gullatt	C.E., U.S. Army	" " "	Engineering Assistant to District Engineer
Capt. Alden K. Sibley	C.E., U.S. Army	" " "	Administrative Assistant to District Engineer
Fifer, Frank P.	Head Engineer (Hydro-Electric)	" " "	Charge of Engineering Division.
Grant, James A.	Principal Engineer (Civil)	" " "	Charge of Operations Division and preparation of final report.
Gay, Howard S.	Principal Engineer (Civil)	" " "	Charge of design of camp and miscellaneous structures.
Buzzell, Dow A.	Principal Engineer (Structural)	" " "	Charge of Dam design.
Stirling, Vincent R.	Principal Engineer (Civil)	" " "	Charge of Navigation facilities.
Harns, Jack E.	Senior Engineer (Civil)	" " "	Head of Miscellaneous structures.
Hayes, Robert H.	Senior Engineer (Civil)	" " "	Head of Lock section.
Haines, Reuben M.	Engineer (S.M.)	" " "	Charge of Soils and Foundations.
Bloch, Edward J.	Engineer (Civil)	" " "	Charge of Land Acquisition.
Brownell, Edward F.	Engineer (Civil)	" " "	Chief of Surveys and Inspection.
Pearce, George P.	Engineer (Mech)	" " "	Charge of Camp design.
Wray, Franklin N.	Engineer (Mat'ls)	" " "	Charge of concrete section.
Angell, Lester W.	Engineer (Structural)	" " "	Dam Design.
Henshaw, Lamond F.	Engineer (Hydraulic)	" " "	Hydraulic studies and cofferdams.

Beall, James F. Jr.	Engineer (Civil)	St. Lawrence River Division.	Lock Design.
Meyerdick, Clarence E.	Engineer (Mech.)	" " "	Construction of camp.
Rosenberg, Benjamin R.	Engineer (Struct)	" " "	Bridge design.
Chase, Charles B.	Attorney	" " "	Land Acquisition.
Dunn, Herbert L.	Abstractor	" " "	Land Acquisition.
Kelson, M.O.C.	Associate Engineer (Structural)	" " "	Charge of contracts, specifications and reports section.
Benson, Mons H.	Associate Engineer (Structural)	" " "	Charge of Contracts, specifications and reports after Mr. Kelson left.
Bondurant, Donald C.	Associate Engineer (Hydraulic)	" " "	Hydraulic Studies.
Slade, Harold R.	Associate Engineer (Civil)	" " "	Construction of Camp.
Moore, Donald C.	Associate Engineer (Civil)	" " "	Operations.
Chun, Edmund H.	Associate Engineer (Structural)	" " "	Dam design and construction of camp.
Fay, Alfred L.	Associate Engineer (Structural)	" " "	Dam Design.
Jermano, Ross R.	Associate Engineer (Civil)	" " "	Construction of camps and roads
Simpson, Willard F.	Associate Engineer (Civil)	" " "	Navigation facilities.
Amrein, W.C.E.	Associate Engineer (Struc)	" " "	Locks.
Wende, Ernest A.	Associate Engineer (Civil)	" " "	Operations, Office Engr.
Gray, Don V.	Associate Engineer (Civil)	" " "	Canals.
Leslie, Dana D.	Associate Engineer (S.M.)	" " "	Soils and Foundations.

Cummins, Omega	Asst. Engineer (Civil)	St. Lawrence River Division.			Land Engineer.
Donovan, Richard J.	Asst. Engineer (Civil)	"	"	"	Dam design.
Steel, David F.	Asst. Engineer (Civil)	"	"	"	Dam design.
Falkenstein, Paul E.	Asst. Engineer (Arch)	"	"	"	Camp design.
Katz, Harold K.	Asst. Engineer (Civil)	"	"	"	Camp design.
Nault, Alfred J.	Asst. Engineer (Civil)	"	"	"	Lock design.
Schaefer, Carleton	Asst. Engineer (Civil)	"	"	"	Camp design.
Cassels, W.L.	Asst. Engineer (Civil)	"	"	"	Contracts, specifications, & reports, also lock design.
Butterfield, G.R. Jr.	Asst. Engineer (Civil)	"	"	"	Soils & Foundations.
Keith, H.A.	Asst. Engineer (Hydr)	"	"	"	Hydraulics.
Lancaster, John H.	Asst. Engineer (Civil)	"	"	"	Operations and Canal design.
Rohwedder, John L.	Asst. Engineer (Chem)	"	"	"	Paint specialist.
Rutherford, Murray J.	Asst. Engineer (Civil)	"	"	"	Construction of camp.
Verville, H. A.	Asst. Geologist	"	"	"	Geology
Capron, Donald L.	Senior Photographer	"	"	"	Charge of Reproduction.
Ruppenthal, Jacob W.	Photographer	"	"	"	Photographer.
Verville, M. J.	Jr. Geologist	"	"	"	Geology.
Mills, Harvey B.	Jr. Engineer (Safety)	"	"	"	Safety.
Keck, William G.	Sr. Engrg. Aide (Civil)	"	"	"	Land Acquisition.

Mericle, Lester E.	Assoc. Land Appraiser	St. Lawrence River Division.	Land Acquisition
Parker, Henry J.	Assoc. Land Appraiser	" " "	Land Acquisition
Fisher, James A.	Asst. Land Appraiser	" " "	Land Acquisition
Lord, Harry N.	Asst. Engrg. Aide (Topo)	" " "	Land Acquisition
Wardell, Frank S.	Engrg. Aide (Civil)	" " "	Land Acquisition
Kelleher, Phillip W.	Principal Law Clerk	" " "	Land Acquisition
Finlay, Roswell L.	Jr. Engineer (Civil)	" " "	Hydraulics.
Kraemer, Eugene A.	Jr. Engineer (Civil)	" " "	Operations.
Lee, William E.	Sr. Draftsman (Topo)	" " "	Operations.
Malakie, T. J.	Sr. Draftsman (Topo)	" " "	Operations.
Beard, Jesse A.	Sr. Draftsman (Topo)	" " "	Operations.
Dabney, James L.	Prin. Engrg. Aide (Comp)	" " "	Computer, Operations
Stiller, B. N.	Jr. Engineer (Civil)	" " "	Chief coreboring Inspr.
Haugen, Conrad G.	Motor Boat Operator	" " "	Launch Operator.
Suberkrup, P. H.	Principal Engrg. Aide (Civil)	" " "	Sr. Party Chief and Field Engineer.
Murphy, J. P.	Jr. Engineer (Civil)	" " "	Party Chief.
Buelow, Jack A.	Sr. Engrg. Aide (Civil)	" " "	Party Chief.
Bufe, B. W.	Sr. Engrg. Aide	" " "	Party Chief.
Kelly, Elmer F.	Jr. Engineer (Civil)	" " "	Party Chief.
Fruend, P. H.	Surveyman	" " "	Party Chief.
Rich, Charles W.	Jr. Engineer (Civil)	" " "	Party Chief.

Leighton-Herrmann, C.	Sr. Engrg. Aide (Civil)	St. Lawrence River Division	Hydraulic design
Johnson, A. W.	Asst. Engineer (Civil)	" " "	Concrete dam design.
Silve, David R.	Prin. Engrg. Aide (Civil)	" " "	Camp construction.
Singman, Charles	Prin. Draftsman (Struc)	" " "	Misc. Structures.
Hyry, John A.	Chief Draftsman (Civil)	" " "	Canals.
Aspinwall, Francis H.	Jr. Engineer (Civil)	" " "	Lock design.
Edelstein, Alvin	Jr. Engineer (Civil)	" " "	Navigation facilities

PART TWO

HYDRAULIC CHANNEL STUDIES

St. Lawrence River Project

HYDRAULIC CHANNEL STUDIES

INDEX

PLATES

Plates

SECTION I SCOPE OF THIS APPENDIX.

1. The hydraulic studies which were made in connection with this report may be grouped under the following headings:

- a. Studies relating to the design of the structures, principally the dams, locks and powerhouse.
- b. Studies relating to the design of cofferdams and diversion channels and the determination of construction schedules and procedures.
- c. Studies relating to the design of the navigation channel.
- d. Studies relating to the design of channel enlargements in certain reaches of the river upstream from the Barnhart Island powerhouse where it is required that velocities be lowered to insure the formation of an ice cover in the winter time.

2. This appendix is concerned with the last two subjects only. The first two subjects, relating to the design and construction of the structures, are covered in the design analyses of the particular structures involved.

3. Plate 1 of this appendix shows the recommended project plan. On this plate may be seen the many channel cuts which will be necessary to make the river satisfactory for navigation and to insure the formation of an ice cover in the winter time. It is the design of these cuts with which this appendix is concerned and for which the studies referred to in items c and d above were made. The particular cuts covered by this appendix are those at the upper end of the project between Chimney Point and Morrisburg, with the exception of the Point Rockaway Canal, and those at the lower end between the head of Cornwall Island and St. Regis Island. The other cuts shown are either slackwater canals or cuts made for diversion during construction.

4. In this appendix, therefore, are described the many hydraulic studies which were made in connection with the design of the above channel cuts. The hydraulic characteristics of the river affecting the design are discussed. The basic data used are listed and described. The methods used in the computations are explained together with the important design assumptions made in connection therewith. Lastly, the results of the studies are presented by reaches.

5. Time did not permit a detailed study of all reaches. The most important reaches however, those having high priority in the construction program, were studied and definite plans of improvement prepared. The less important reaches were left for future study. Where detailed studies were not made, a design closely approximating the Canadian plan was used.

6. It is intended that the results of the computations shall eventually be checked by model tests. Analytical methods alone cannot be depended upon to insure a satisfactory navigation channel. An attempt has been made to solve analytically such problems as the division of flow among the various channels making up the International Rapids Section of the St. Lawrence River and the determination of the maximum velocity in the portion of the channel which will be used for navigation, but at best these solutions can be considered only rough approximations since it is impossible to put into equation form all of the factors influencing the design. Some problems, such as the determination of the location and magnitude of cross currents and eddies are not even susceptible of an analytical solution. The sizes of cuts can be determined approximately by analytical methods, but the detailed shape and proper location of these cuts cannot. To insure a satisfactory navigation channel, therefore, it is considered desirable that all of the critical reaches be checked by model tests and that the details of the channel cuts be worked out in the model. Canadian engineers associated with this project have also expressed their desire that this be done.

7. Plates 1, 2, 3, 4 and 34 of Appendix III-C (1) show the detailed layout of the channel cuts and enlargements which are covered by this appendix.

SECTION II. HYDRAULIC CHARACTERISTICS OF ST. LAWRENCE RIVER

8. Description of St. Lawrence River. Plate M of the main report contains a small scale map and profile of the whole St. Lawrence River system. On this map it may be seen that the St. Lawrence River system consists basically of three parts, - the Great Lakes (Lake Superior, Lake Michigan, Lake Huron, Lake Erie and Lake Ontario), the St. Lawrence River proper, and the Gulf of St. Lawrence. The City of Quebec marks the head of the gulf and the lower end of the river. Kingston on the Canadian side and Tibbetts Point on the American side mark the upper end of the river and the beginning of the lake.

9. The St. Lawrence River proper is 342 miles long. The upper 114 miles, between Lake Ontario and St. Regis constitute the International Boundary between the United States and Canada. Downstream from St. Regis, the river is entirely within Canadian Territory. Between Chimney Point and Montreal, also a distance of 114 miles, the river is generally constricted and steep. Forty-six miles of this steep portion is in the international section and 68 miles in the Canadian section. Locks are necessary for navigation in this steep portion, as may be seen on the profile on Plate M of the main report. The 68 miles above the steep portion and the 160 miles below, are quite flat and locks are not necessary in these reaches.

10. The river above Montreal may be divided into five more or less distinct sections as follows; (1) the deep lake-like reaches of the Thousand Islands Section, 68 miles in length from Lake Ontario to the first swift water near Chimney Point; (2) the International Rapids Section embracing the 46 miles of rapids and swift water between Chimney Point and Lake St. Francis; (3) the Lake St. Francis Section extending 27 miles through that lake to the end of deep water at its foot; (4) the Soulanges Section embracing the 18 miles of rapids and shoal waters from Lake St. Francis to Lake St. Louis; and (5) the Lachine Section including Lake St. Louis and the rapids and to Montreal harbor, a distance of 23 miles. These 5 sections are indicated on the insert map on Plate M referred to above.

11. Description of International Rapids Section. The International Rapids Section is indicated on the general map on Plate M of the main report. It will be noted that there are no major tributaries in this section. One small tributary, the Grass River, enters the Section near the lower end. Another small tributary, the Oswegatchie River, enters a few miles upstream from the upper end of the Section. The natural flow from these tributaries has very little effect upon the large flow of the St. Lawrence River, and for the purposes of this report have been neglected. Diversions for power are often appreciable, however, and must be considered. The most important diversion is at Massena, New York, where about 25,000 c.f.s. is diverted. This flow returns to the Section through the Grass River.

12. Plate 1 of this appendix shows the International Rapids Section

in detail. It will be noted that this section of river contains numerous islands of all sizes. These islands break the river into many channels, which channels are themselves quite crooked and irregular. The Section consists mostly of rapids and reaches of swift, smooth-flowing water. Velocities are generally high and watersurface slopes steep. The total fall through the entire 46-mile Section is about 92 feet.

13. The steep slope starts at the head of Galop Island. The north and south channels past Galop Island are called the Galop Rapids, the north channel being called the Canadian Galop Rapids and the south channel, the American Galop Rapids. Below Galop Island the river flows through an irregular channel with varying reaches of swift and relatively slower flow to the Rapide Plat in the upper end of the Ogden Island north channel. Most of the fall in the Ogden Island north channel occurs in the Rapide Plat, while most of the fall in the Ogden Island south channel take place at Waddington near the lower end of the island where the channel is obstructed by a causeway and the remains of an old dam. Below Ogden Island the river flows through a series of islands to Chrysler Island, whence the channel is unobstructed to Steens and Cat Islands at the head of Croil Island. Here Croil Island and Long Sault Island again split the river into two principal channels. The largest of the rapids, the Long Sault rapids, begins near the middle of Long Sault Island north channel and ends at the foot of that island. The Long Sault Island south channel is a series of minor rapids throughout its entire length. Below Long Sault Island the main channel (Barnhart Island south channel) is a section of swift water. The final rapids occur at the lower end of the Barnhart Island north channel. Below Barnhart Island the river flows swiftly to the head of Cornwall Island where it is again split into two channels which enter into Lake St. Francis near the foot of that island. Of the total fall of 92 feet in the International Rapids Section, 10 feet are concentrated in the Galop Rapids, 12 feet in the Rapide Plat, 29 feet in the Long Sault Rapids and 9 feet in the Barnhart Island (north channel) Rapids. A profile of the natural river channel for a flow of 240,000 cfs is shown on Plate M-III of the main report. Profiles for 216,000 and 280,000 cfs are shown on Plate 11 of this appendix.

14. Present Navigation Channel. The International Rapids Section has been developed for 14-foot navigation on the Canadian side of the river. Lateral canals, by-passing the steeper portions of the section, were constructed by the Dominion of Canada early in the present century. At the head of the section, the Galop Canal by-passes the Galop Rapids and swift water downstream to Iroquois; near the head of Ogden Island the Morrisburg Canal by-passes the Rapide Plat and swift water to Morrisburg; the Farran's Point Canal carries navigation around the swift water at the head of Croil Island; and the Cornwall Canal system goes around the Long Sault Rapids and swift water downstream to below Cornwall. These canals are shown in plan on Plate 1 of this appendix and in profile on Plate M-III of the main report. The controlling dimensions of the locks are: length 252 feet; width 44 feet; and depth over sills 14 feet. Further data on the locks may be found in a publication of the Department of Transport of Canada, entitled "Canals of Canada".

15. <u>Discharge Characteristics of River</u>. The St. Lawrence River is unique among the rivers of the world in that the tremendous storage capacity of the lakes regulates the flow to an unusual extent. The average monthly outflow of Lake Ontario, from 1860 to 1940, was 237,000 cubic feet per second; the maximum, 314,000 cubic feet per second; the minimum, 144,000 cubic feet per second. The drainage area above St. Regis, N. Y., located at the foot of the International Rapids Section, is approximately 303,000 square miles, of which 95,000 square miles are water surface. This large discharge and drainage area make the St. Lawrence River one of the larger rivers of the world.

16. The discharge characteristics of the St. Lawrence River have been studied for many years by governmental and private agencies in both Canada and the United States and by international boards. Many stream gages have been established in connection with these studies, and many stage and discharge records obtained. The location of the gages are shown on Plate 1 and on Plates 2 to 9 of this appendix. The latest study of the discharge characteristics of the river, incorporating the results of all previous studies, was made by the Canadian Department of Transport. The results of this study are presented in a report entitled "Document No. 2, Lake Ontario Levels, Outflows, Supplies and Regulation, General Engineering Branch, Department of Transport, Ottowa, September 1940". Extensive use was made of this report by this office and it is reproduced herewith as Part Two, Exhibit I of this appendix.

17. The above report contains a tabulation of monthly average Lake Ontario levels at the Oswego, N.Y. gage for the 80-year period from 1860 to 1940, together with the monthly average outflows of the lake for this period. Monthly averages were used in each case, because the variation within the period of a month was not considered sufficient to affect the results of the study. Because there are no large tributaries between the lake and the International Rapids Section, outflows of the lake were assumed to be the same as the flows in the Section. Tables 1 and 2, copied from Document No. 2, show the results of an analysis of the above 80-year stage and discharge record.

TABLE 1. WATER LEVELS OF LAKE ONTARIO

	Water Levels at Oswego, N. Y.	
	Actual	With outlet conditions as at present and with continuous diversion of 3,200 c.f.s. at Chicago
Mean water level elevation	245.96	246.34
Minimum monthly mean (Nov. 1934)	242.68	242.93
Minimum daily mean (Nov. 26, 1934)	242.50	242.75
Maximum monthly mean (May, 1870)	249.02	249.66
Maximum daily mean (May 1, 1870)	249.19	249.83
Minimum yearly mean (1935)	243.54	243.78
Maximum yearly mean	247.63 (1886)	248.21 (1870)
	Number of months.	
No. of months above elevation 249.50	0	2
" " " " " 249.00	1	8
" " " " " 248.50	9	40
" " " " " 248.00	45	85
" " " below " 244.50	99	53
" " " " " 244.00	39	26
" " " " " 243.50	18	10
" " " " " 243.00	5	3

TABLE 2. OUTFLOWS FROM LAKE ONTARIO

	Outflows in 1,000 c.f.s. Actual	Outflows in 1,000 c.f.s. Assuming continuous diversion of 3,200 c.f.s. at Chicago
Mean outflow - 1860 - 1869	261	258
1870 - 1879	249	246
1880 - 1889	252	249
1890 - 1899	231	228
1900 - 1909	237	238
1910 - 1919	233	238
1920 - 1929	224	229
1930 - 1939	207	211
Mean 1860 - 1939	237	237
Minimum monthly mean (Feb. 1936)	144	148
Maximum monthly mean (May 1862 and 1870)	314	311
Minimum yearly mean (1934)	181	186
Maximum yearly mean (1861)	281	277
Monthly mean flow 75% of time	217	218
" " " 35% " "	249	249
" " " 20% " "	262	263

	Number of months	
No. of months above 300,000 c.f.s.	12	9
" " " " 290,000 "	36	30
" " " " 280,000 "	71	69
No. of months below 210,000 c.f.s.	185	178
" " " " 200,000 "	122	112
" " " " 190,000 "	59	55
" " " " 180,000 "	23	20

18. It will be noted in Tables 1 and 2 that, in addition to the actual values, values are also given for a continuous diversion of 3200 c.f.s. by the Sanitary District of Chicago. Diversion has actually varied during the 80-year period from a minimum monthly mean of 1400 c.f.s. in January, 1900 to a maximum of 10,800 c.f.s. in June 1924. In 1930, the Supreme Court of the United States decreed that this diversion must be reduced to 1500 c.f.s. In addition to this diversion by the Sanitary District, there is at present an average pumpage for domestic purposes of about 1700 c.f.s. The total, 3200 c.f.s., was taken by the Department of Transport as the total diversion to be counted on in the future. Natural lake levels and outflows have been corrected for this difference in diversion in order to show the effects of diversion and project operation separately.

19. Tables 1 and 3 of Document No. 2 show actual lake levels and outflows and Tables 2 and 4 show the corrected values. The corrected values are shown in hydrograph form on 8 drawings numbered 2198, in this document. Plates 1 and 2 of the above document show 10-year average hydrographs for both the actual and corrected values, in addition to duration curves for both.

20. Since the lake levels change very slowly and since tributary flow is relatively insignificant in the International Rapids Section, single line rating curves can be used at all gaging stations to represent present flow conditions. An analysis of all the gage and discharge records obtainable for this section of river was made by this office and rating curves established for the most important gages. These curves are shown on Plate 10 of this appendix. As previously stated, Plate 1 and Plates 2 to 9 of this appendix show the location of the gages. It should be kept in mind when using the rating curves on Plate 10 that they apply to open river conditions only. When the river is frozen, stage-discharge relations change frequently and the preparation of useful rating curves is not feasible. Department of Transport Document No. 2 contains a chart (Plate 9 of Part Two, Exhibit I of this appendix) showing the rating of the outlet of Lake Ontario in terms of elevations on the Oswego gage.

21. The discharge characteristics of the present river channel are also shown in profile form on Plates 2 to 9 inclusive and Plate 11 of this appendix. The first group of plates contains the standard low water profile prepared by this office from miscellaneous discharge data. The standard low water discharge established by the U.S. Lake Survey - 197,000 c.f.s., was used for this profile. Two other profiles are shown on Plate 11 of this appendix, one for 216,000 c.f.s. and one for 280,000 c.f.s. These were prepared from elevations given on Canadian Department of Transport drawings No. 2136. The elevations for 247,000 c.f.s. are also given on drawings No. 2136. Water levels are also shown on the 1" = 500' scale hydrographic maps prepared by this office, The elevations are shown on both sides of straight lines drawn across the river on these maps. The straight lines represent the ends of reaches to which the elevations apply. These elevations were used in transferring soundings to elevations and are the water levels corresponding to the U.S. Lake Survey standard low water. Other water level data on file in the District Office consists of surveys of short reaches made by this office and other agencies.

22. The Hydro-Electric Power Commission of Ontario has made discharge measurements at various critical points in the International Rapids Section to determine the division of flow at points where the channel is divided by islands. Some of these records have been copied by this office and are on file in computation file Sy-2-4/2.

23. A survey of surface current conditions in the International Rapids Section was made by this office and maps prepared showing the results (Plates 18 to 22 of this appendix). These maps show current directions and magnitudes and also the location of surface boils and rapids.

24. The above rating curves, profiles, discharge measurements, and current conditions apply to the existing channel only. After the improvements are made conditions will be entirely different and the above data will not be applicable. Water levels will no longer be controlled by the natural characteristics of the channel, but by the operation of the Long Sault and Iroquois dams, and the Barnhart Island powerhouse. Also friction losses between points will be changed by the channel, cuts and enlargements. The above data will be useful, however, in connection with any channel models that are made. It will be needed in calibrating the models, that is obtaining the proper model roughness under existing conditions before experimenting with the improvements. The data was also found useful in the design computations for the channel cuts, described later on in this appendix. The profiles were used to determine natural roughness factors of the river, which could be applied in the backwater computations.

25. Regulation Method No. 5. At present, outflows of Lake Ontario are controlled by the constriction and rapids at Galop Island. All plans of improvement considered in this report contemplate the removal of this constriction in order to satisfy navigation requirements and the transfer of control to a dam to be constructed at Iroquois Point. The present control at Galop Island has resulted in certain variations in Lake Ontario levels, to which all improvements bordering the lake have adjusted themselves. It would not be possible to change these levels appreciably without causing considerable damage to riparian property. It was also desired to keep approximately the same seasonal variation in discharge so as not to affect appreciably the present river characteristics and fluctuations in lake levels. It was particularly desired that the minimum flow not be reduced because of possible effects on water levels in Montreal harbor and reduced power benefits. It was desired that the maximum spring discharge not be exceeded in order that the flood problem downstream would not be aggravated. Also any increase in the maximum discharge would make larger navigation cuts necessary in order to keep velocities down. Likewise, it was not desired to increase the winter flow appreciably because larger cuts would have to be made to insure the formation of an ice cover. It was therefore early recognized in studies of this project that, if the natural control at Galop Island is to be removed and a variable control in the form of a dam substituted, operating rules would have to be established for the dam which would insure the same general seasonal variation in outflows and lake levels that exist at the present time.

26. The subject of operating rules has been given much study by all concerned with this project over a period of many years. The Joint Board in connection with its 1926 Report gave it considerable study. Since that time the Canadian Department of Transport has been studying the problem, attempting to formulate definite rules for the operation of the dam and the regulation of lake levels and outflows. Several regulation methods were tried. Each method was tried on the 80-year period of records from 1860 to 1940 to see how it would work. The method found to be most satisfactory was the one designated "Method No. 5". This methods was designed to meet the following requirements;

a. To keep the fluctuations of the levels of Lake Ontario within the levels that would have resulted in the past, assuming a continuous diversion of 3,200 c.f.s. at Chicago and present outlet conditions.

b. To maintain, without impairment, the low water levels of Montreal Harbour.

c. To maintain low flows during the winter period December 15 to March 31, in order that the difficulties of winter power operation may not be aggravated.

d. To maintain flows during the first half of April no greater than would naturally occur, in order to avoid the danger of aggravating the spring rise during the breakup of the ice below Montreal.

e. To avoid any material increase in the amount and duration of the high discharges during May, in order not to aggravate high water levels in Lake St. Louis during the Ottawa floods.

f. To keep the fluctuation in monthly mean discharges within the limits as existed in nature.

g. To hold back the natural excess outflow during the early summer months, in order to raise the ordinary levels of Lake Ontario.

h. To secure the maximum dependable flow throughout the year for power operation.

27. Document No. 2 (Part Two, Exhibit I of this appendix) describes the extent to which each one of these requirements is satisfied by the operation of Method No. 5. Tables 8 and 9 and Plates 1 and 2 of that document show in detail the results of applying Method No. 5 to the monthly mean hydraulic factors for the 80 years of record. For convenient reference a summary of these results is given herewith in Tables 3, 4 and 5. In all this work it was assumed that a diversion of 3200 cubic feet per second was made at Chicago and that 5000 cubic feet per second was added to the supply of the St. Lawrence River by diversion into Lake Superior of that amount from Long lac and Ogoki River, both of which are

in the Hudson Bay drainage area. (See Article VIII, Paragraph (b) of the International Agreement of March 19, 1941.)

TABLE 3. MONTHLY MEAN DISCHARGES

(in 1,000 c.f.s.)

	IN NATURE		UNDER REGULATION
	Actual	Continuous diversion of 3,200 c.f.s.	Method No. 5 Div. 3200 c.f.s. Add. 5000 c.f.s.
Maximum	314	311	310
Minimum	144	148	180
*Mean	237	237	242
35% of time	249	249	253
65% of time	226	227	223
		Number of Months	
At maximum	2	2	44
300 and above	12	9	59
Below 200	122	112	44
" 190	59	55	15
" 180	23	20	0

*NOTE: This line not in Document No. 2; data obtained from Tables 3, 4 & 8 of Document No. 2.

TABLE 4. MONTHLY MEAN LAKE LEVELS
(Oswego, N. Y.)

	IN NATURE		UNDER REGULATION
	Actual	Continuous diversion of 3,200 c.f.s.	Method No. 5 Div. - 3200 c.f.s. Add. - 5000 c.f.s.
Maximum	249.02	249.66	249.10
Minimum	242.68	242.93	243.77
Minimum during navigation season	242.68	242.93	244.03
		Number of Months	
Total Period.			
Above elev. 249.5	0	2	0
" " 249.0	1	8	3
" " 248.5	9	40	14
" " 248.0	45	85	50
Below elev. 244.5	99	53	17
" " 244.0	39	26	3
" " 243.5	18	10	0
" " 243.0	5	3	0
Navigation Season Only.			
Below elev. 244.5	40	23	4
" " 244.0	18	11	0
" " 243.5	7	4	0
" " 243.0	2	1	0

TABLE 5. WATER LEVELS IN MONTREAL HARBOR

		IN NATURE		UNDER REGULATION
		Actual	Continuous diversion of 3,200 c.f.s.	Method No. 5 Div. 3200 c.f.s. Add. 5000 c.f.s.
Minimum monthly mean elev.		17.15	17.37	17.60
		Number of Months.		
Below elev.	18.99	32	37	26
"	18.50	13	16	12
	18.00	8	8	6
	17.50	3	1	0

28. This office has accepted the results of the above study and adopted Method No. 5 in its design computations. All power studies were based on the monthly mean regulated discharges summarized in the foregoing tables.

29. Backwater Curves for Use with Method No. 5. In addition to establishing rules for the regulation of Lake Ontario, the Department of Transport made a complete backwater study of the International Rapids Section under improved conditions. This was necessary in order to determine whether control by dams at Iroquois Point and at the foot of Long Sault Island would be feasible and also to determine the range of water levels throughout the Section. The latter was necessary in order to design the navigation channel and to enable sufficient cross-sectional area to be provided in the winter time to insure the formation of an ice cover. This back water study was made assuming the channel improved in accordance with the latest plan prepared at that time, the Controlled Single Stage Project 238-242, shown on Plate M-II of the main report. This plan will hereafter be referred to as the "Original 238-242 Plan" in order to distinguish it from the plans prepared by this office, which are also controlled single stage projects, but differ slightly from the Original 238-242 Plan (see Plates M-I and M-IA of the main report).

30. The results of the above backwater study are given in a report entitled, "Document No. 4, Controlled Single Stage Project, Backwater Calculations and Hydraulics, Department of Transport, General Engineering Branch, Ottawa, November 15, 1940". A copy of this report is available in the files of this office. This report contains a brief description of the methods of backwater computations used and a presentation of the results in the form of gage relation curves. Relations were prepared for the following points: Lake Ontario at Oswego, N.Y.; Butternut Island; Below Lotus Island; Above Iroquois Dam; Below Iroquois Dam; Barnhart Island Powerhouse. Curves are given for both ice cover and open river conditions. In computing these curves the assumption was made that all gates in Iroquois Dam are wide open. By means of these curves, the water level at any of the above points on the river can be determined from a given level at the Oswego gage in Lake Ontario, for any discharge possible under Method No. 5 operation. It should be kept in mind however, that these curves apply to improvement in accordance with the Original 238-242 Plan only.

31. Since the plans prepared by this office are practically identical with the Original 238-242 Plan used in the preparation of the above curves as far as channel cross-section area is concerned, in all reaches except the Galop Island reach between Butternut Island and Lotus Island, all of the above backwater relationship curves except this one could be applied directly to the plans prepared by this office. This greatly simplified the backwater computations of this office. It was necessary only to correct the Butternut Island - Lotus Island relationship to make it conform to the computations of this office. This was done by computing the loss between these two points for the maximum flow of 310,000 c.f.s. and then making the loss for other flows proportional to the squares of the discharges. This will be explained in more detail in Section V.

32. All of the backwater computations of this office were tied into Canadian computations at Chimney Point, - the upper end of the project. Since this was not one of the points used in the gage relationship curves, it was necessary for this office to compute the loss between the Butternut Island gage and Chimney Point. This could be done without any appreciable error because the drop in watersurface between these points is extremely small, - only about 0.3 of a foot for the maximum discharge. The water levels used by this office and those used by the Canadians in the computations of the Original 238-242 Plan, therefore, are the same at Chimney Point. Below this point they differ due to the difference in improvement plans in the Galop Island reach. Since the plans of this office contemplate more extensive enlargement in the Galop Island reach, the losses in this reach will be smaller and water levels below Galop Island will in general be higher than in the Original 238-242 Plan.

33. Watersurface profiles for six selected discharge conditions and for improvement according to the Original 238-242 Plan are shown on Plate 11 of this appendix. These levels were taken directly from Document No.4. Corresponding levels at Lotus Island and the Barnhart Island Powerhouse under the plans prepared by this office are shown on Table 9 in Section VI. The higher levels under the plans prepared by this office are clearly apparent in this table.

34. Ice Conditions in the St. Lawrence River. Ice is usually present on the St. Lawrence River from about the middle of December to the end of March, during which period navigation has to be suspended. Although this ice cover is a hindrance to navigation, it is expected to be an advantage to power, as it will prevent the formation of frazil ice in the area which it covers and will also prevent floating ice from reaching the powerhouse intake. Any reduction in frazil and floating ice reaching the powerhouse will mean much less trouble with clogged racks and turbine passages, with resulting increased power generation. Experience with other hydro-plants in this latitude shows that considerable expense is warranted in maintaining an ice cover on the pool in the winter time. These factors undoubtedly influenced the Joint Committee to include in its 1941 recommendations a provision that constricted sections of the channel upstream from the powerhouse be enlarged to lower winter velocities to the point where an ice cover will be secured. The exact criterion set up for carrying out this provision is discussed in more detail in Section IV.

35. The basis for the criterion for ice cover was a study made by the Joint Board of Engineers in their 1926 report (Appendix E). This board found that an ice cover, or bridge, will form completely across the surface of a channel having an average velocity of less than 1¼ to 1½ feet per second. Floating ice and slush will pack upstream therefrom against an average velocity of about 2½ feet per second before the floating slush is drawn under the ice cover and will form downstream with velocities up to about 2 feet per second. As a result of this study it was concluded that;

a. "Smooth ice covers may be expected to form in rivers with velocities up to 1.25 feet per second in zero weather provided there is no high wind preventing such action".

b. "Ice covers may be expected to pack upstream up to a velocity of 2.25 feet per second without danger of ice going under the cover".

These findings were accepted by the Joint Committee in their 1941 report and were made the basis of the present design (see Section IV).

36. Power and Industrial Developments. Several off-channel power and industrial developments draw water from the river. The largest of these, the hydro-electric power plant of the St. Lawrence River Power Company as Massena, New York, draws a nominal maximum of 25,000 c.f.s., although the demand is increased at times to 27,000 c.f.s. or more if the stage of the river is such that no interference with navigation levels will result. This diversion, however, does not affect the design of the channel cuts covered by this appendix, because this water leaves and enters the river in a reach of river in which there are no such cuts. A weir has been placed across the Long Sault Island south channel near the head of the island to divert the required flow into the Massena Power Canal, through which it is delivered to the power plant. The tailrace discharges into the Grass River which flows into the St. Lawrence at the head of Cornwall Island well below the sites of the Long Sault Dam and Barnhart Island Powerhouse. The new St. Lawrence project has been so designed that its construction will not interfere materially with the operation of this plant but it is contemplated that the plant will ultimately be abandoned because the water can be more advantageously utilized at the new Barnhart Island Powerhouse.

37. Other developments take water from the river through the Cornwall Canal system. The powerhouse at Sheek Island takes water from Bergen Lake and returns it to the Barnhart Island north channel above the Barnhart Island powerhouse site. This powerhouse must be abandoned shortly after the beginning of project construction. The developments located below the Barnhart Island powerhouse site, and which will continue in operation for an indefinite period after completion of the project are as follows:

a. Cornwall Street Railway, Light and Power Co.; 57 c.f.s. taken from above Lock 17 and returned to river.

b. Howard Smith Paper Mills Ltd.; 1800 c.f.s. taken from above Lock 18 and returned to canal below Lock 18.

c. Canadian Cottons Ltd.; - two licenses - 780 c.f.s. and 1220 c.f.s. taken from above Lock 17 and returned to river.

d. Corporation of the Town of Cornwall; 120 c.f.s. taken from above Lock 18 and returned to river.

SECTION III. HYDRAULIC DATA USED IN THE STUDIES

38. The following is a list and description of the more important hydraulic data contained in the files of this office:

a. Canadian Sources.

(1) Department of Transport.

(a) Document No. 2, Lake Ontario, Levels, Outflows, Supplies, and Regulations, Department of Transport, Ottawa, September 1940. (Contains tables, hydrographs, duration curves, and other analyses of monthly mean outflows of Lake Ontario and the effect on these flows of Regulation Method No. 5). Printed as Part Two, Exhibit I, of this appendix.

(b) Document No. 3, Discharge, Stage, and Water Level Relationships, Department of Transport, Ottawa, November 1940. (Contains rating curves at Oswego, Kingston, Prescott, Locks 28, 27, 25, 24, 23, and 21 and gage relation curves.)

(c) Document No. 4, Controlled Single Stage Project, Backwater Calculations and Hydraulics, Department of Transport, Ottawa, November 15, 1940. (Contains gage relation curves of completed Original 238-242 Project and description of methods used in backwater calculations)

(d) Drawings No. 2136, Sheets 1 to 5, scale 1" = 1000' (Show topography, hydrography, tabulation of water levels for 216,000, 247,000 and 280,000 c.f.s., and Original 238-242 Plan; hydrography is based on U. S. Survey data obtained prior to 1926.)

(2) Department of Mines and Resources;

(a) Monthly mean water levels at Cornwall (Lock 15), 1900-1941; Summertown, 1920-1941; and Coteau Landing, 1919-1941.

(3) Hydro-Electric Power Commission of Ontario.

(a) Automatic gage hydrographs, 1919-1921 (incomplete) at North Channel, Lock 27, Lock 25, Rockway Point, Morrisburg (Lock 23), Brunner's Point, Bradford Point, Farran's Point, Richards Landing, Dickinson Landing (Lock 21), and Cornwall (Lock 15).

(b) Tabulations of daily mean water levels for short periods in 1919 and 1920 at various portable automatic gage

stations from Chimney Island to Leishman Point.

(c) Daily staff gage readings at various points, Chimney Points to Iroquois (1918-1921); Murphy Island to foot of Croil Island (1919-1921); and Rapide Plat (1915 and 1919).

(d) Discharge measurements (1918-1920) showing distribution of flow in various channels from Galop Island to Croil Island.

(e) Map showing location of gages.

(4) <u>Miscellaneous Canadian Sources.</u>

(a) 5 sheets (8"x10½") Slopes from Polly's Gut to foot of Cornwall Island (North and South Channels) and through Polly's Gut - both natural and improved conditions.

(b) H.E.P.C. Map-location of gages, Lock 21 to Lock 15.

(c) H.E.P.C. Profile-water surface profile Lock 21 to below Cornwall Island.

(d) Unclassified map - water levels around Cornwall Island May 26-28, 1921 and tabulation to accompany same.

(e) Unclassified blueprint map - water levels around Cornwall Island May 26-28, 1921.

(f) Unclassified blueprint - water levels Mille Roches to Cornwall - November 1920.

(g) Unclassified blueprint - water levels around Barnhart Island Sept. 13 and 14, 1921

(h) Unclassified blueprint - water levels - Cornwall to Johnstown - June 14 to 24, 1921.

(i) Unclassified blueprint - water levels around Long Sault Island - October 1-8, 1919.

(j) Unclassified blueprint - water levels around Long Sault Island, Sept. 15-20, 1921.

(k) Unclassified blueprint - water levels around Ogden Island - September 8-10, 1921.

(l) Unclassified blueprint - water levels around Ogden Island - November 1920.

(m) Unclassified - blueprint - water levels Chimney Point to head of Galop Island - Sept. 6-7, 1921.

(n) Unclassified blueprint - water levels Galop Island to Iroquois - Nov. 1920.

(o) Dept. of Transport - Winter water levels at tailrace of Sheeks Island Powerhouse (1912-1941). Also winter water levels vicinity of Cornwall and Barnhart Island 1924-27.

(p) Unclassified - One roll of blueprints showing ice conditions vicinity of Cornwall for various periods.

b. <u>American Sources.</u>

(1) <u>U. S. Lake Survey</u>.

(a) Report entitled, "Discharge of St. Lawrence River", by H. F. Lawhead dated May 6, 1937, (Presents equations expressing river discharge in terms of water surface elevations at Oswego, Cape Vincent, Ogdensburg, Locks 27, 25, and 24, Waddington, Tracy Land (South Sault Channel); readings at all gages for several discharges; data for standard low water profile (197,000 c.f.s.). A study of the accuracy of the above equations was made by this office and was reported in a memorandum by Mr. H.A. Keith.

(b) Four reports entitled, "Hydraulics of the St. Lawrence River", dated 1913, 1914, 1916 and 1917, the first three by W. S. Richmond and the last by Sherman Moore.

(c) Daily mean water levels at Oswego, 1940, 1941; Cape Vincent, 1941; Ogdensburg, 1940, 1941; Waddington, 1941.

(d) Monthly mean water levels (complete) at Oswego, 1860-1940; Cape Vincent, 1916-1940; Ogdensburg, 1901-1907 and 1920-1940; Waddington, 1938-1940.

(e) Monthly mean water levels (incomplete) at Oswego, 1837-1859 and 1941; Cape Vincent, 1898, 1914, and 1941; Ogdensburg, 1900, 1908, 1911, 1913, 1914, 1919, and 1941; Waddington 1936, 1937 and 1941.

(f) Discharge records.

(g) Soundings of St. Lawrence River, 1939-1940, reduced to M. S. L. by this office.

(2) Aluminum Company of America (Massena)

(a) Daily staff gage readings for various years between 1907 and 1920 at various points from Lock 24 to mouth of Grass River. Also at Tracy Landing from 1937 to 1941.

(b) Winter high water elevations of Grass River at powerhouse tailrace (hourly tailrace elevations available at Alcoa plant offices).

(3) Hugh L. Cooper Engineering Company.

(a) Set of prints from report of survey and investigations (includes rating curves, backwater data, and channel coefficients).

c. Reports of International Joint Boards and International Agreements

(1) St. Lawrence Waterway, Report of the United States and Canadian Government Engineers on the Improvement of the St. Lawrence River from Montreal to Lake Ontario made to the International Joint Commission, dated June 24, 1921, Senate Document No. 179, 76th Congress, 2nd Session. (Sometimes called "Wooten-Bowden Report")

(2) St. Lawrence Waterway, Report of the International Joint Commission concerning the Improvement of the St. Lawrence River between Montreal and Lake Ontario for Navigation and Power, dated December 19, 1921, Senate Document No. 114, 67th Congress, 2nd Session.

(3) St. Lawrence Waterways Project, Report of Joint Board of Engineers, dated November 16, 1926, with Appendices. (Contains design criteria for original project and special report on ice studies.)

(4) St. Lawrence Waterway Project, Report of Joint Board of Engineers (Reconvened) on the International Section of the St. Lawrence River, dated April 9, 1932. (Contains good detail maps of International Section.)

(5) St. Lawrence Deep Waterway, International Rapids Section, Joint Report of Canadian Temporary Great Lakes - St. Lawrence Basin Committee, and the United States St. Lawrence Advisory Committee, dated Jan. 3, 1941. (Contains design criteria for present project.)

(6) Text of an Agreement between the Governments of the United States and Canada pertaining to the St. Lawrence River, dated March 19, 1941, House Document No. 153, 77th Congress, 1st Session.

d. <u>Hydraulic computations, memoranda, and drawings made in connection with this report by the District Office and the Office, Chief of Engineers.</u> (Only important hydraulic drawings listed.)

(1) St. Lawrence River Project, International Rapids Section, Plan and Profile (8 drawings; scale 1" = 1000') Shows river stations, location of gages, and standard low water profile.

(2) St. Lawrence River Project - Tentative Backwater Profiles, Drawings BD - A - 1/D, Plate XIV - D. (Shows natural profiles for 216,000 and 280,000 c.f.s. and pool conditions after completion of Original 238-242 Plan.)

(3) St. Lawrence River Project, International Rapids Section, Profiles (1 drawing; scale 1" = 1 miles). (Shows 3 profiles, one in main channel of river, one along navigation channel, and one in existing 14-foot navigation channel.)

(4) St. Lawrence River Project, International Rapids Section, Rating curves (1 drawing). Shows rating curves for all rated gages in the International Rapids Section.

(5) St. Lawrence River Discharge - Method No. 5 from 1860 to 1939, Months of April through November of each year only. (Graph showing monthly average flows of Method No. 5 for the navigation season only).

(6) Monthly Mean Outflows of Lake Ontario for Dec. & Jan. 1860 - 1940, Method No. 5 (Graph showing monthly average flow of Method No. 5 for the months of December and January).

(7) Galop Rapids - Canadian Plan, Maximum Velocity in Navigation Channel vs Width of Galop Cut. (Graph from which 850-foot width of cut was obtained).

(8) U.S.E.O. Plan, Galop Island Canal Showing Canal Width Necessary to Limit Maximum Velocity Shown at Critical Method No. 5 Conditions and Number of Years During Which One Month Will Exceed 4'/sec. (Graph from which 1600-foot width of cut was obtained).

SECTION IV CRITERIA FOR DESIGN OF CHANNEL CUTS.

39. Development of Design Criteria. Because of the great amount of study which had been given this project previously, the rules and criteria of design had been fairly well established before the present studies were begun. Engineers of this office, therefore, first familiarized themselves with the results of previous studies. Conferences were held with engineers of the various government departments and private companies which had been concerned with the project. Since the design of the channel cuts was primarily a navigation problem and since the Canadian Department of Transport had been studying this problem for the past several years, the most valuable assistance was obtained from engineers of that Department. Many conferences were held between engineers of this office and those of the Department of Transport, both before and during these hydraulic studies in order to make sure that the personnel of this office fully understood all of the factors influencing the design of the channel cuts. The purpose of this section of the appendix is to set forth these factors.

40. Although most of the factors, or criteria as they are called below, apply to all reaches where channel cuts were made, it was not necessary to make a detailed study in order to apply each one to a particular reach. Usually two or three of them would be the controlling ones and the others would be automatically fulfilled by designing for the controlling criteria. It was necessary sometimes, however, to back check to see that all applicable criteria had been satisfied. The detailed application of criteria to particular reaches of the river is covered in Section VI of this appendix.

41. The Design Criteria. The following are the important criteria used in the design of the channel cuts;

a. General Plan. The International Agreement of March 19, 1941 adopted the recommendations contained in the Joint Report of the Canadian Temporary Great Lakes - St. Lawrence Basin Committee and the United States St. Lawrence Advisory Committee, that;

> "---the development of the International Rapids Section of the St. Lawrence River --- be undertaken in general accordance with the plan of the 238-242 Controlled Single Stage Project ---".

The "238-242 Controlled Single Stage Project" is the plan shown on Plate M-II of the main report and is the one designated "Original 238-242 Plan" in this appendix. A comparison of this plate with Plate M-I of the main report will show that the plan recommended by this office is almost identical with the above plan. Minor changes in location of structures and cuts have been made but these only as a result of more complete foundation explorations or hydraulic computations. The Original 238-242 Plan is shown in more detail on 5 drawings, No. 2136, of the Canadian Department of Transport. Details of the plan recom-

mended by this office are shown on Plates 1, 2, 3, 4, 19 and 34 of Appendix III-O(1).

b. Minimum Dimensions of Navigation Channel.

(1) The Joint Board of Engineers, in its report dated November 16, 1926, used the following criteria for the minimum dimensions of the navigation channel (Appendix C, Par. 13):

"In general, navigation channels are not less than 200 feet bottom width when flanked by two embankments, not less than 300 feet when flanked by one embankment, and not less than 450 feet when both sides of the channel are submerged.---------The minimum radius of curvature adopted is 5,000 feet with at least one-quarter miles of tangent between reversals. The alignment is drawn so as to eliminate cross-currents wherever possible."

The above channel dimensions are based on a 25-foot deep channel, which was the project depth at that time. In 1932, the Joint Board of Engineers (reconvened) recommended an increase in project depth to 27 feet. The Original 238-242 Plan is based on this depth. This depth was again recommended in the Joint Committee report of 1941 and incorporated in the International Agreement of 1941. The following is quoted from the Annex of the International Agreement:

"All navigation channels to be excavated to 27-foot depth".

In the preparation of the Original 238-242 Plan, Canadian engineers decided to keep the same width at the 25-foot depth, thereby making the new bottom widths less than the above values. Thus additional side excavation was avoided. Side slopes of 2:1 were assumed throughout. Therefore bottom widths decreased 8 feet in all cases, - from 200, 300, and 450 feet to 192, 292, and 442 feet, respectively. These reductions in bottom width were also adopted by this office.

(2) Very little occasion was found, however, to use the minimum dimensions or radius of bend given above, as an inspection of Appendix III-O(1) will show. It was generally felt that the above dimensions were too small for the large vessels and inexperienced crews likely to use the channel, except possibly in very quiet water. Crews of ocean-going vessels are not used to navigating in a limited space or against an appreciable current. Also experience on the Great Lakes has shown that widened and straightened channels pay dividends in increased capacity and reduced mishaps. It was considered advisable, therefore, to increase the above minimum dimensions for all except slack-water channels. In the open river and in cuts where appreciable velocities are encountered, bottom widths considerably greater than the above have been used, as will be noted on the plans. In most cases, however, these greater widths were needed for additional dis-

charge capacity so that very little additional expense was involved in using wider and straighter channels. So far as possible the navigation channel has been laid out as a series of straight courses, rather than as a series of curves, because experience has shown that it is easier for pilots to follow straight courses than sinuous curves. At the bends, however, channels have been widened on the inner side to provide ample maneuvering space.

c. Maximum Velocities in Navigation Channel.

(1) The criterion for navigation channel velocities used by the Joint Board of Engineers in its 1926 report was as follows (Appendix C, Paragraph 13):

"In cases where navigation is carried through restricted stretches of river, a sectional area of 65,000 square feet is provided at mean stage. This is equivalent to a sectional area of about 70,000 square feet at high stages, and a maximum velocity somewhat less than 5 feet per second in such channels."

This criterion was used by the Canadians in the design of the Original 238-242 Plan.

(2) The International Agreement of March 19, 1941, changed this criterion slightly. The following is quoted from the Annex of the International Agreement:

"Channel enlargement from the head of Galop Island to below Lotus Island designed to give a maximum velocity in the navigation channel south of Galop Island not exceeding four feet per second at any time."

The reason for mentioning the Galop Island reach especially was that this is the only reach above the Long Sault Dam where this criterion controls. There is another reach below the dam, the Cornwall Island reach, where this criterion should also be applied but it was not so stated in the agreement. It has been assumed that the intent of the above paragraph was that at no place in the International Rapids Section is the velocity in the navigation channel to exceed 4 feet per second.

(3) In applying this criterion, it was felt that undue expense should not be incurred to prevent this velocity from being exceeded by a small margin for a short period of time at a few points in the channel. An understanding was reached with engineers of the Department of Transport to the effect that velocities in excess of 4 feet per second would be allowed to occur during about 3% of the navigation season, provided that the maximum did not go over 4.5 feet per second.

(4) The discharge which is of interest in connection with this criterion is the maximum to be expected during the navigation season. Since the greatest flows in the International Rapids Section occur during the navigation season, the maximum flow to be allowed during that period is the critical one to be considered. In Table 3 it may be seen that maximum flow to be permitted under Method No. 5 is 310,000 c.f.s. This flow will occur at several lake levels as Tables 8 and 9 of Department of Transport Document No. 2 (Part Two, Exhibit I, of the appendix) show. Since the lowest lake level will result in the highest velocities in the International Rapids Section, it is the lowest level that is of interest in connection with this criterion. The lowest level according to Tables 8 and 9 is El. 246.78. Since the Canadian engineers had used a lake level of El. 246.5, a slightly more conservative figure, in the design of the Original 238-242 Plan, it was decided to use the same elevation in the computations of this office to make the results comparable. The above lake levels refer to the Oswego, N.Y., gage. The design of the Galop Island reach, therefore, was based on a discharge of 310,000 c.f.s. and a lake level of El. 246.5. Cuts were designed to reduce velocities in the navigation channel for this condition to about 4.5 feet per second.

d. Maximum Velocity on January 1st.

(1) The findings of the Joint Board of Engineers on the subject of hydraulic conditions which induce the formation of an ice cover on the water surface of a river such as the St. Lawrence were presented in paragraph 35 above. As a result of these findings, a clause was included in the Joint Committee Report and again in the International Agreement of March 19, 1941, as follows:

"Channel enlargement between Lotus Island and the control dam and from above Point Three Points to below Ogden Island designed to give a maximum mean velocity in any cross section not exceeding two and one-quarter feet per second with the flow, and at the stage, to be permitted on the 1st of January of any year, under regulation of outflow and levels of Lake Ontario."

The reason for including the specific reaches in this requirement was that previous studies by the Canadians had shown that these reaches were the only ones above Long Sault Dam where it was economically feasible to fulfill this requirement. This left two shorter reaches where it was considered uneconomical to meet the requirement, as follows:

(a) Galop Island reach, from Chimney Point to below Lotus Island, where the preceding criterion of 4 feet per second is to be used.

(b) The short narrow reach of river just below Iroquois Dam, which will not be used for navigation. It is recognized that frazil ice may form in these two reaches but the exposed area is not considered large enough to cause trouble at the power plant.

(2) All of the channel cuts within the reaches mentioned in the quotation above were designed for this criterion as this was the controlling one for these reaches. According to this criterion, a velocity of 2.25 feet per second must not be exceeded on January 1st of any year. Inspection of the hydrograph of regulated flow in Department of Transport Document No. 2 (Plate 12) will show that on January 1st the flow is always decreasing. The largest flow that will exist on January 1st will be the worst condition as far as velocities are concerned, the reason being that the stages are so nearly the same for all of the winter flows in the International Rapids Section. A plot of January flows and lake levels given in Tables 8 and 9 of Document No. 2 shows the maximum flow to be 221,000 c.f.s. An enveloping line passing through the lowest lake levels shows the lowest lake level for each flow. This line passes through El. 247.0 at a flow of 220,000 c.f.s., which is the condition selected for design.

(3) It is assumed that the Department of Transport used ice cover conditions in computing January elevations. Therefore, the above condition is probably for full ice cover. The criterion of 2.25 feet per second must also be fulfilled for the open river condition which exists just prior to the start of the formation of an ice cover, in order that the ice sheet will start to form. In order to determine the water surface level which will exist with this open river condition, the December flows and lake levels were plotted on a graph and an enveloping line drawn through the lowest lake levels. The largest December flow is 268,000 c.f.s., but it is assumed that it will always be possible to reduce the flow to about 220,000 c.f.s. on January 1st, since the maximum January flow is 221,000 c.f.s. The lowest lake level for a flow of 220,000 c.f.s., as indicated by the enveloping line, will be about El. 245.7. The worst flow condition at the start of the formation of the ice sheet will be an open river condition with a flow of 220,000 c.f.s. and a lake level of El. 245.7. According to the preceding paragraph, the worst flow condition at the completion of the ice cover will be an ice cover condition for the same flow and a lake level of El. 247.0. At any time during the formation of the ice cover, therefore, a condition somewhere between these two conditions will prevail. If the velocity criterion for these limiting conditions are satisfied, it is assumed that all conditions between will be satisfied.

(4) The water levels throughout the International Rapids Section for the above two conditions were computed using

the backwater curves of Department of Transport Document No. 4 and correcting the results so as to be applicable to the improvement plan recommended by this office for the Galop Island reach. The following results were obtained.

<u>Minimum January 1st Water Levels for 220,000 c.f.s.</u>

Condition of River	Lake Ontario	Butternut Island	Lotus Island	Above Iroquois	Below Iroquois	Barnhart Is. Powerhouse
Ice cover	247.0	244.85	244.15	<u>243.13</u>	242.82 (242.12)	239.1 (238.0)
Open river	245.7	244.42	<u>243.8</u>	243.5	243.2 (<u>240.0</u>)	241.6 (<u>238.0</u>)

The figures without parentheses are for the condition of an unlimited pool height at Long Sault Dam (or Barnhart Island Powerhouse). The figures in parentheses are for the condition which will exist during the initial period when the pool at Long Sault Dam is limited to a maximum of El. 238.0 in accordance with the provision of the International Agreement of 1941 (Article IV), as follows:

"(e) Upon the completion of the works provided for in the International Rapids Section, the power works shall be operated, initially, with the water level at the power houses held at a maximum elevation 238.0 ---------------- for a test period of ten years or such shorter period as may be provided by any board or authority designated ------."

The underscored numbers are the critical water levels which should be used in the design of the channel cuts "between Lotus Island and the control dam and from above Point Three Points to below Ogden Island", as specified in the first quotation above. The channel cross section in these reaches should be made large enough to reduce the average velocity to 2.25 feet per second with a flow of 220,000 c.f.s. at these levels.

(5) The variation of the water level between Iroquois Dam and the Barnhart Island Powerhouse is not shown in the above table because the backwater curves in Document No. 4 do not show levels for any intermediate points. This variation should be computed, however, when work on the project is again resumed, so that the water levels in the reaches where cuts have to be made will be more accurately known. The cuts shown on the plans were actually designed for a level grade of El. 242 above Iroquois Dam and a level grade of El. 241 downstream from the dam, which is conservative above the dam but not so below the dam.

e. Water Levels at Chimney Point to Remain Unchanged.

(1) The 238-242 Controlled Single Stage Project to which all plans considered in this report in general conform, provides for two dams, - Long Sault Dam and Iroquois Dam. Long Sault Dam is the main power dam, while Iroquois Dam is merely an auxiliary dam to insure the proper regulation of Lake Ontario levels and outflows. The water level at Long Sault Dam will be raised about 70 feet by the dam. The drop through the Iroquois Dam will ordinarily be a few feet. It will be less than a foot when all gates are open.

(2) A level pool from Long Sault Dam, at either El. 238 or El. 242, would extend upstream to the foot of Galop Island. Assuming existing channel conditions to prevail, the backwater slope would be such as to raise the water level at Chimney Point and in Lake Ontario 2 or 3 feet above existing levels. This would be contrary to the first requirement of Method No. 5, given in Section II, as follows:

> "To keep the fluctuations of the levels of Lake Ontario within the levels that would have resulted in the past, assuming a continuous diversion of 3,200 c.f.s. at Chicago and present outlet conditions."

(3) It will be seen, therefore, that it would not be satisfactory to leave the channel in its present condition even if velocities were satisfactory for navigation and ice conditions. There must be some channel enlargement in any plan of improvement in order to satisfy this backwater condition. Actually, none of the channel cuts were designed for this condition but the extent to which this condition is met by the cuts of the Original 238-242 Plan may be seen on Plate 11 of this appendix. On this plate, the backwater curves for 6 critical Method No. 5 discharge conditions are shown. These backwater curves show the variation in pool level at Long Sault Dam and the Barnhart Island powerhouse necessary to make lake levels and outflows conform to Method No. 5, and hence remain within the bounds of existing conditions. Table 4, in Section II of this appendix, shows the extent to which Method No. 5 conforms to existing conditions.

(4) With improvement in accordance with the Original 238-242 Plan, the minimum and maximum headwater levels at the Barnhart Island Powerhouse would be El. 231.0 and El 242.2, as may be seen on Plate 11 and Table 9 of this appendix. This minimum is for ice cover conditions. For open river conditions, the minimum would be E. 235.5. These values were taken directly from the backwater curves of Department of Transport Document No. 4. Corrections were later

applied to these values to make them comparable to the values obtained for the plans prepared by this office. The corrected values are El. 232.5, El. 242.5, and El. 237.0, respectively. These values are also shown on Table 9 under the column heading "Orig. 238-242 Plan (adj)". In the next column on this table, are shown the corresponding values for the recommended plan of this office, which has larger cuts in the Galop Island reach than the Original 238-242 Plan. The main fluctuation in the case of the recommended plan would be from El. 235 to El. 242.7, with a minimum for open river conditions of El. 238.2.

(5) A comparison of the elevations given above will show that a saving in power head can be realized by enlarging the channel and reducing the water surface slope. This factor is treated separately in the next criterion, criterion f, although it will be readily seen that the two factors, - limiting lake levels and saving power head, are interrelated and must of necessity be discussed together. The two factors have been separated because there are two distinctly separate objectives to be accomplished. The major objective, which is covered by this criterion, is to see that a general pool level of about El. 240 is possible without affecting lake levels. The second objective, covered by Criterion f, is to see whether or not any additional excavation would be warranted in view of the power head saved. The latter is more of a refinement of the first.

(6) The above elevations show that the first objective has been met in the case of the recommended plan of this office and the Original 238-242 Plan. That is, the channel cuts in these plans are sufficiently large to permit the maintenance of a pool level of El. 240, plus or minus, at Long Sault Dam without affecting Lake Ontario levels or outflows. Continuing the above line of reasoning, the next step would normally be to determine the optimum amount of excavation considering power benefits. Another factor comes into the picture at this point, however, the amount of excavation required for reduction of navigation channel velocities. This makes an economic comparison of the above two plans unnecessary because the larger cuts of the recommended plan are necessary to satisfy the velocity requirement. However, all of the increased cost of the larger cuts is not chargeable to navigation. A benefit to power is also accomplished, as represented by the increased power head available. This economic factor would also come into the picture if it should be desired to consider a plan with still larger cuts in the Galop Island reach. As will be seen later in Section VI under the discussion of the Galop Island reach, this factor was considered in comparing the

two plans developed by this office for this reach, one of which had a larger cut than the recommended plan.

(7) There is no upper limit to the amount of channel excavation that can be carried out above Long Sault Dam, other than economics. If the pool at Long Sault Dam tends to get too high, the gates of Iroquois Dam can be lowered and lake levels and outflows controlled from that point. The above elevations cited are based on a wide-open Iroquois Dam. Also, with Iroquois Dam in operation the pool at Long Sault Dam can be lowered to any desired level without affecting lake levels or outflows.

(8) It will be noted that "Chimney Point" was used in the heading of this criterion, instead of "Lake Ontario". Regulation Method No. 5 is given in terms of Lake Ontario elevations but since no improvement is contemplated between Lake Ontario and Chimney Point, Method No. 5 could just as well have been expressed in terms of elevations at Chimney Point, the head of the project. Actually what was done in the computations was to determine equivalent Method No. 5 elevations at Chimney Point and work from these elevations, holding Chimney Point elevations constant. Hence the use of "Chimney Point" in the heading.

(9) This criterion is obviously not applicable to improvements below Long Sault Dam, since conditions below the dam cannot affect Lake Ontario levels or outflows.

f. Reduction in Friction Slope to Increase Power Head.

(1) Under the preceding criterion, it was brought out that any channel enlargement upstream from the Barnhart Island powerhouse will result in higher pool levels at the powerhouse and hence increased power head. Channel enlargement below the power house will likewise result in increased power head, due to decreased tailwater elevation. Power benefits, therefore, are a factor to be considered both upstream and downstream from the powerhouse.

(2) This factor is important in connection with the design of channel cuts in the Galop Island reach because this reach is at the upper end of the pool where the slope is steep and any reduction in friction loss in this reach is magnified at the powerhouse. It is not likely that this would be the deciding factor in a choice of plans, however, unless the saving was quite great. On the other hand if it should be found that two plans for this reach were equally desirable from a navigation standpoint, the power benefit might be the deciding factor. The importance of this factor however cannot be determined until the model studies are completed and the importance of the navigation

factors are known. It must be remembered that most of this increase in power will become available only if and when the International Commission authorizes the operation of the project with an elevation greater than 238 in the Barnhart Island Pool.

(3) This factor will also be important in connection with the design of the Cornwall Island reach because the sizes of cuts in this reach will affect tailwater elevations at the Barnhart Island powerhouse. However, as will be explained later, this is one of the reaches which this office had to leave for later study and there was no opportunity to bring this factor to bear. The excavation directly below the powerhouse is specifically for the purpose of lowering tailwater levels and should be considered along with the Cornwall Island cuts in any future study.

g. Maintenance of 14-Foot Navigation During Construction.

(1) It is important that the existing 14-foot navigation shall not be interfered with during the construction of any part of the project, either structures or channel cuts. It was necessary, therefore, to make a hydraulic check of the effect of construction on watersurface elevations at the various locks and canals on the Canadian side of the river. Where the use of a lock or canal was interfered with, an alternate route had to be provided.

(2) During the construction of Long Sault Dam, the pool above the dam will be raised to various intermediate stages before reaching the initial pool elevation of 238. Appendix III-22(3), Section XIV contains a detailed description of the construction and closure schedule. It is briefly as follows;

(a) During the first and second stages of construction, the water level at the dam is to be kept at about El. 195.

(b) During the closure period the water level at the dam will be raised successively to elevations 201, 209, 225, and 235.

(3) Navigation in the 14-foot canals will not be interfered with until the pool level reaches about EL. 207, at which elevation the Farran's Point Canal will be drowned out and navigation will have to use the river. When the pool at the dam is raised above El. 209, the Cornwall Canal will be drowned out. However, in this case navigation will be able to use the new Long Sault Canal, which will be suitable for 14-foot navigation at a pool level of El. 225. During the rise from El. 209 to El. 225, the

Morrisburg Canal will also be drowned out and navigation will have to use the river in this reach. In the last case, channel cuts proved to be necessary to lower velocities sufficiently to permit 14-foot navigation. Since cuts in this reach had already been shown to be necessary to satisfy criterion d above, no additional cuts were necessary. However, this meant that the cuts must be completed early enough in the construction program to permit their use when the pool at the dam is raised to El. 225.

(4) There is one instance where a cut must be delayed in order to avoid interference with 14-foot navigation. Complete excavation of the Point Three Points cut must await the rise of pool level to El. 225 in order not to lower stages too much at Lock 25 to permit use of the lock by 14 foot navigation. Since the low water depth on the lower sill of Lock 25 is 16 feet, some excavation at Point Three Points can be done without reducing this depth below 14 feet.

h. Economics.

(1) In laying out the channel cuts, economics also played an important part. Differences in amount and class of excavation, in method of excavation and inavailability of spoil areas influenced the detailed location of the cuts. Advantage was taken of the latest soundings of the Lake Survey and the foundation explorations of this office. An attempt was made to obtain the least costly solution consistent with the other criteria.

(2) Criterion f will also enter into the economics, particularly in the Galop Island and Cornwall Island reaches.

SECTION V. METHODS OF BACKWATER COMPUTATION.

42. General. The computations made in connection with the design of the channel cuts consisted mostly of backwater computations. The problem was usually one of finding water surface slopes and velocities for certain improved channel conditions and certain critical pool levels at Long Sault Dam. Ordinarily such a problem would be relatively simple. In this case, however, the river is so cut up with islands and individual channels are so irregular in cross section that special methods had to be used in the solution of most of them. A brief description of the methods used is given below.

43. Division of Flow. The large islands in the International Rapids Section divide the river into two main channels. In some sections, small islands split the flow still further. The improvement calls for cuts through the islands in some places, producing additional channels of flow. Because of this complicated pattern of flow, it was necessary in most reaches to guess or approximate by rough methods the division of flow among the various channels before starting the backwater computations. After the backwater had been computed with this assumed distribution, the drops between common points had to be checked to see that they were consistent. If not, the flows would have to be adjusted to make them consistent. Fortunately, due to extensive previous work on this project, water levels could be estimated very closely at the start and recomputation of the hydraulic properties of sections or recomputation of the backwater was not usually necessary. In most cases, the discharge could be adjusted by the simple relation,

$$\left(\frac{Q_2}{Q_1}\right)^2 = \frac{S_2}{S_1}$$

where Q_1 and S_1 are the assumed flow and computed slope respectively and Q_2 and S_2 the corrected values for the same channel. This relation comes from the Manning Formula,

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$$\text{or } Q = AV = A \frac{1.486}{n} R^{2/3} S^{1/2}$$

where A, n, and R are assumed to be constant. When it is considered that bottom sounding are given only to the nearest foot and that the first trial of backwater computations usually came within a few tenths of the correct answer, it will be seen that the assumption of constant A and R is not at all unreasonable.

44. Backwater Formula. The Backwater computations of this office were based on the Manning Formula,

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Canadian computations were based on the Chezy Formula,

$$V = c\sqrt{rs}$$

with Bazin's value of c,

$$C = \frac{157.6}{1 + \frac{m}{\sqrt{r}}}$$

45. Cross Sections. Cross sections were located on the large 1" = 500' scale base maps prepared by this office from the latest Lake Survey soundings. Sections were taken at close intervals in order to show each major change in area or type of section. Sections were located at the extremes of area, i.e., at the narrowest and widest points. This permitted computation of expansion (or eddy) losses. The hydraulic properties of the end sections were averaged to obtain the properties of a typical section for the reach. Cross sections were plotted on graph paper and curves of area and hydraulic radius drawn. Where it was obvious that a part of the channel would be ineffective, this part was blocked out and omitted in the computation of the section properties. Maps showing the location of the cross sections and the cross sections themselves are contained in the computation files of this office (SY-C-4/2).

46. Roughness Factors and Eddy Losses. The Canadians had determined roughness factors for the natural channel based on the Bazin formula and applied them in the computation of Method No. 5 backwater curves for the Original 238-242 Plan given in Department of Transport Document No. 4. This office likewise undertook the computation of roughness factors for the existing channel for use in computing backwater. The computations of this office, however, were based on the Manning formula. Also, an attempt was made to separate friction losses from eddy (or expansion) losses. The Canadian roughness coefficients included all losses. It was felt that a more accurate answer could be obtained for the improved channel and raised pool conditions if these losses were considered separately, because it is generally recognized that if a channel is straightened and enlarged the eddy losses will be changed even though the surface roughness remains about the same. Also, in the computations of this office, the slope of the energy gradient was used instead of the water surface in an attempt to obtain greater accuracy.

47. The method used to separate the friction and eddy losses for the natural channel is described in detail in a memorandum entitled, "Memorandum on the Hydraulic Effect of the Bonneville Dam" by J. C. Stevens, Consulting Engineer. A copy of this memorandum is contained in the computation files of this office (SY - C - 4/2). Briefly, the method consists of plotting the energy gradient of the channel by adding the velocity head to the water surface elevation at each cross section; adjusting this energy gradient to a continuous downward slope by connecting the high points with straight lines; figuring hypothetical discharges at each section based on this adjusted energy gradient and the observed water surface; subtracting the actual discharge from this hypothetical dis-

charge to obtain an imaginary eddy flow; dividing the total drop between sections into two parts proportional to this eddy flow and the actual flow; and then computing the roughness factor (Manning's "n") for each reach from the portion of drop corresponding to the actual flow. The drop corresponding to the eddy flow was called the "eddy loss" and the drop corresponding to the actual flow the "friction loss."

48. In computing backwater with the above "n" values and eddy losses, the same principles were used in reverse order. In the case of backwater in a part of the channel in which there was to be no improvement, the same ratio of actual velocity head to hypothetical velocity head was used, assuming the eddy loss to be the same proportion of the total loss. In the case of a radically improved channel the hypothetical velocity head was assumed to be the same as the actual velocity head, assuming the eddy loss to be entirely eliminated by the improvement. In cases of partial improvement, the hypothetical velocity head was assumed to be somewhat between the above two values depending upon the degree of improvement.

49. It was recognized that the above method might not be reliable in the case of the reaches of river consisting largely of rapids, - such as the Galop Island reach. A check method was therefore applied to the Galop Island reach. This method consisted of finding a deep section of river which would closely represent conditions in the Galop Island reach after the pool is raised and then determining the friction and eddy losses for this reach and applying the results to the rapids section. The Toussaints Island reach (from Lotus Island to Iroquois Point) was selected as being typical of the Galop Island reach after the pool is raised. A study of this reach showed the average "n" value to be about .025 and eddy losses, expressed in terms of the difference in velocity heads at the ends of expanding reaches, to be on the average about $.35\Delta h_v$. These values were considered to apply to Galop Island natural channels. In comparison, it was thought that an "n" of .020 and expansion losses of $.50\Delta h_v$ would be about right for artificial cuts. It was not so important that the "n" values be absolutely correct as it was that they be relatively correct, that is, have about the same relative values as the correct values. This would give the correct division of flow among the various channels although the watersurface slope might be incorrect. Since the division of flow was the most important problem in this reach, use of the above values was considered safe.

50. Check computations for the Galop Island reach were also made in the Office, Chief of Engineers, using the same general method of the one just described, except that expansion losses were assumed to be $.50\Delta h_v$ for both natural and artificial channels. This value was considered more representative of present day practice in the computation of expansion losses in natural channels. The U. S. Geological Survey uses this value in its flood determination in natural channels by the slope-area method. This value was also used by J. C. Stevens in an example of a natural channel in an article entitled "Computing Backwater Curves for surface slopes in streams" in the October 1, 1925 issue of Engineering News-Record, page 550. Values of $.50\Delta h_v$ and greater were used for natural channels in the book "Regulation of Elevation and Discharge of the Great Lakes" by John R.

Freeman, 1926, pages 302-303. The Office, Chief of Engineers did not consider that enough is known about this factor for natural channels at the present time to use other than generally accepted value of $.50\Delta h_v$.

51. A very precise method of computation was attempted by the Office, Chief of Engineers in its check of the Galop Island reach. Roughness factors were considered to vary from cross section to cross section, instead of being assumed constant for great lengths of channel. Different roughness factors were also used for different parts of a single cross section where the degree of improvement differed in the various parts. Manning's "n" was varied between the limiting values of .020 and .025 according to judgment. Where a single cross section consisted of two or more almost separated channels or where the hydraulic radii of the various parts were radically different, the total discharge was divided among the parts in accordance with the ratios of conveyance factors of the parts and the flow in each part treated separately. Velocity heads and energy losses of the various parts were computed separately and weighted values determined for the ends of the reach. Because of the small sizes of these losses and velocity heads and the extremely flat slopes involved, computations were carried to the third place beyond the decimal.

52. As stated in a previous section of this appendix, this office made extensive use of the gage relation curves in Department of Transport Document No. 4 in its backwater studies. Check computations made in this office indicated that these curves are essentially correct. As previously stated, these gage relation curves are based on improvement in accordance with the Original 238-242 Plan. Since the channel cuts in the plans proposed by this office are practically the same size as those in the Original 238-242 Plan, except for the Galop Island reach, these curves have been adopted by this office as representing the correct backwater relations for all reaches except the Galop Island reach and for all improvement plans considered in this report.

53. The gage relation curves in Document No. 4 are based on natural "n" values. As previously stated, natural "n" values are not considered applicable to backwater in the Galop Island reach because of the rapids. Therefore, in using the curves of Document No. 4, a correction was always made for the difference in backwater slope in the Galop Island reach. The water surface slope as computed by this office for this reach was always used. Table 6 of this appendix shows the differences in roughness factors used by the Canadians and by this office in backwater computations of the Galop Island reach.

Table 6. ROUGHNESS VALUES FOR GALOP ISLAND REACH

Channel	Department of Transport				This Office	
	Bazin's "m"	Hyd. Rad.	Equi. Manning's "n"	Aver. "n"	Actual "n"	Corrected "n"
No. Channel	5.7 to 7.0	13 to 30	.034 to .043	.038	.025	029
So. Channel	4.8 to 5.5	16 to 26	.031 to .036	.034	.025	029
Galop Cut	4.2	24 to 27	.030	.030	.020	023

54. It will be noted in Table 6 that the "n" values used by this office have been corrected for purposes of comparison with the Canadian values. As previously stated, the Canadian coefficients include both friction and eddy losses. Therefore, the coefficients of this office had to be increased to include eddy losses. By totalling all losses and the eddy losses alone in several reaches it was found that the eddy losses were on the average about 25% of the total losses. This factor was used in correcting the "n" values of this office. Since n varies as $S^{\frac{1}{2}}$, the actual n's were multiplied by the factor, $\sqrt{\frac{1}{.75}}$, to obtain the corrected values.

55. It will also be noted that the Canadian values are higher than the values used by this office. The slope through the Galop Island reach for identical improvement plans will therefore be greater in the case of the Canadian computations. The curves in Document No. 4, may therefore be expected to show a greater drop through the Galop Island reach than the computations of this office.

56. The following method was used to correct for this difference in slope through the Galop Island reach. If, for instance, it was desired to find the water level above Iroquois Dam for a given Lake Ontario level and outflow, the curves in Document No. 4 showing the relation between Lake Ontario and Lotus Island would first be used, then that showing the relation between Lotus Island and Butternut Island. Thus the water level at Butternut Island would be determined. Then the loss computed by this office between Butternut and Lotus Islands would be subtracted from the Butternut elevation to obtain the corrected Lotus Island elevation. The curves showing the relation between Lotus Island and Iroquois Dam would then be used to find the water level above Iroquois Dam. Document No. 4 contains curves for both open river and ice cover conditions. Care must be taken, therefore, to see that the right curves are used. The curves showing the relation between Lake Ontario and the Barnhart Island powerhouse cannot be used because there is no way of making the Galop Island correction with these curves. In making comparisons between the various improvement plans of this office and the Original 238-242 Plan, it is always necessary to make certain that the plans being compared are based on the same backwater assumptions, on other words, that the above correction has already been made. Otherwise, part of the difference noted may be due to a difference in method of computation rather than to differences in the plans.

57. More detailed descriptions of the methods used in the backwater computations are contained in the computation files of this office (SY - C - 4/2). Details of the Canadian methods are contained in Canadian Department of Transport, Document No. 4. Check computations of the Galop Island reach by the Office, Chief of Engineers, are also contained in the computation files of this office.

SECTION VI. HYDRAULIC STUDIES BY REACHES.

58. General. In this section, the design of the individual reaches is taken up. The important hydraulic studies made in connection with the design of each reach are described in detail. Also important general studies affecting the design of more than one reach are discussed. In cases where general studies have been adequately covered in preceeding sections reference is made to the paragraphs where these previous discussions may be found. The following order has been used in presenting the studies:

a. General studies.

b. Galop Island reach and Galop Canal.

c. Toussaints Island reach.

d. Point Three Points reach.

e. Ogden Island reach and Morrisburg Canal.

f. Croil Island north channel and Farran's Point Canal.

g. Cornwall Canal.

h. Cornwall Island reach.

59. As previously stated, time did not permit a complete study of all reaches. All but the last one listed above, however, received at least an approximate analytical analysis. Very little was done on the Cornwall Island reach. It will be necessary to start from the beginning on the design of this reach when work on the project is resumed. The Galop Island reach received the most study because hydraulic conditions in this reach are most severe and the cost of improving this reach will be considerably greater than any other reach. It is the only reach above the Long Sault Dam which will be designed for the maximum navigation velocity. All other reaches upstream from the dam are designed for ice cover conditions which result in lower navigation velocities. This will be readily seen, when it is realized that waterlevels will be about the same for all discharges when the project is completed and that a channel designed for a winter flow of 220,000 c.f.s. at 2.25 feet per second will have a velocity of about 3.2 feet per second at the maximum summer discharge of 310,000 c.f.s. This is considerably less than the maximum navigation velocity of 4.5 feet per second used in the design of the Galop Island reach.

GENERAL STUDIES

60. The most important general studies which were made in connection with the design of the channel cuts are the following:

a. Natural roughness factors and eddy losses.

b. Check of backwater for Original 238-242 Plan.

c. Backwater with no improvements above Iroquois Point.

d. Analysis of Lake Ontario discharges and levels.

e. Standard low water profile.

f. Rating curves at important gages in International Rapids Section

61. Natural Roughness Factors and Eddy Losses. As stated in the preceding section (par.46), natural roughness factors and eddy losses were determined for the existing river channel for use in the backwater studies. The natural water surface profile for a discharge of 247,000 c.f.s. was used for this purpose. The reach covered in this study was from Chimney Point to Doran Island (below Canada Island), which is the critical reach as far as the channel cuts are concerned. The methods used in these calculations are explained in par. 47 of the preceding section. The calculations are on file in computations files SY - C - 4/2.

62. Check of Backwater for Original 238-242 Plan. In Section II, it was stated that the Canadian Department of Transport had computed backwater for the Original 238-242 Plan and expressed the results in the form of gage relation curves in Document No. 4. It was also stated that this office made extensive use of these curves in its backwater studies but that a few check computations were first made to determine the accuracy of these curves. These computations are described below.

63. The Galop Island reach was used for this check. The drop between Lotus and Butternut Islands was computed and compared with the value obtained from Canadian drawing No. 2329 in Document No. 4. Two methods of computation were used, - one, the method desribed in Par. 47 of the preceding section where a hypothectical energy gradient is constructed and friction and eddy losses computed and the other, a method similar to that used by the Canadians where only roughness factors are considered. In the latter method average "n" values equivalent to the Canadian "m" values were used. A fairly good check was obtained by both methods. It was concluded therefore, from this check of the Galop Island reach, that all of the gage relations are essentially correct, based on the assumption that roughness factors of the improved channel will be identical with those of the existing channel.

64. As to the reasonableness of the last assumption the following may be said. This office used the Canadian curves below Lotus Island only. Below Lotus Island channel improvements are not very extensive. Therefore "n" values of the channel may be expected to remain about the same and from this standpoint no greater error is introduced by using natural values. On the other hand, there are some rapids below Lotus Island and as previously mentioned (par. 45 above) natural "n" values determined from rapids are not reliable when applied to deep and quiet flow. Also, in the lower end of the pool depths are increased to such an extent that it is questionable whether any roughness factors determined from natural conditions would be reliable. However, since there are no precise methods for computing backwater under extremely deep pool conditions, this office

considered the Canadian curves to be about as accurate a solution as could be obtained. The Canadian curves may be considered conservative, also, in that their use probably resulted in showing steeper slopes than will actually prevail since the effect of the improvements and the quieter flow should be to reduce the roughness factors below those existing under natural conditions.

65. Backwater With No Improvements Above Iroquois Point. In Section IV, under the discussion of Criterion e., paragraph 41 e. it was pointed out that a certain amount of channel enlargement is necessary in the upper reaches of the pool of Long Sault Dam to prevent backwater from affecting Lake Ontario levels. It was also stated that a study had shown that lake levels would be raised 2 or 3 feet above their present levels if no channel enlargements were made. The study made to determine this increase in lake levels is described below.

66. The study consisted of 2 backwater computations, - one for a pool level of El. 238 at Long Sault Dam and one for El. 242. A discharge of 247,000 c.f.s., which is close to the average discharge of the river (see Table 3 in Section II), was used in both computations. The computations were started at Iroquois Point, assuming Method No. 5 elevations to prevail at this point. Iroquois Dam was assumed to be out and the river upstream from the dam to be in its natural state. The computation method described in paragraph 47 of the preceding section was used, -- the one where a hypothetical energy gradient is used and friction and eddy losses are considered separately.

67. The results of the computations are shown in profile form on a sheet of graph paper in computation file SY - C - 4/2. With pool El. 238, the lake was raised 1.8 feet above the natural elevation or 2.9 feet above Method No. 5 elevation. With pool El. 242, the lake was raised 3.2 feet above the natural elevation and 2.1 above Method No. 5 elevation. Hence the statement in Section IV, that the lake will be raised 2 or 3 feet if no channel enlargements were made.

68. Analysis of Lake Ontario Discharges and Levels. An analysis of Lake Ontario levels and discharges was made for use in determining the most severe hydraulic conditions upon which to base the design of the cuts in the Galop Island reach. All of the monthly average discharges and lake levels given in Tables 8 and 9 of Department of Transport Document No. 2, for the months of April to November inclusive, were plotted on a graph entitled "St. Lawrence River Discharge - Method No. 5, From 1860 to 1939, Months of April through November of each year only" (computation file Box D - 16). An enveloping line drawn through the lowest points on this graph would represent the severest combinations of lake level and discharge during the navigation season. Such a line would show the lowest water surface for a given discharge or the greatest discharge for a given water level, which are the conditions which result in the highest velocities in the navigation channel. It may be seen on this graph that the condition of 310,000 c.f.s. discharge and a lake level of El. 24[illegible].5 falls practically on this line. This is the condition recommended by the Department of Transport and adopted by this office for the design of the Galop Island

reach (see par. 41c (4) of Section IV).

69. Table 7 shows the severest combinations of lake levels and discharges which will prevail during the navigation season (April thru November) under regulation Method No. 5. A line drawn through these points would be the same as the line referred to in the preceding paragraph.

Table 7. Lowest Lake Levels for Navigation Season (Apr. thru Nov.) Discharges According to Method No. 5.*

Year	Month	Discharge (c.f.s.)	Lake Level
1869	Oct.	310,000	246.78
1885	Nov.	305,000	6.26
1869	"	302,000	6.18
1876	"	288,000	6.14
1866	"	280,000	6.08
1883	"	276,000	6.05
1884	"	251,000	5.90
1904	"	249,000	5.80
1882	"	243,000	5.74
1874	"	239,000	5.70
1893	"	236,000	5.67
1867	"	234,000	5.52
1930	"	232,000	5.49
1921	"	224,000	5.46
1901	"	221,000	5.38
1891	"	216,000	5.14
1932	"	214,000	5.11
1939	"	211,000	4.93
1935	Sept.	202,000	4.91
1933	Oct.	201,000	4.85
1936	Nov.	198,000	4.78
1934	Aug.	193,000	4.72
1933	Nov.	190,000	4.52
1935	Apr.	187,000	4.28
1934	Oct.	183,000	4.20
1934	Nov.	180,000	244.03

*Note: Taken from Tables 8 and 9 of Dept. of Transport Document No. 2.

Table 8. Lowest Lake Levels for Winter (Dec. thru Mar.) Discharges According to Method No. 5.*

Year	Month	Discharge (c.f.s.)	Lake Level
1861	Dec.	268,000	247.02
1878	"	254,000	6.57
1876	Mar.	250,000	6.52****
1860	Dec.	246,000	6.19
1885	"	244,000	6.31
1890	"	234,000	6.03
1917	"	231,000	5.92
1929	"	227,000	6.08
1876	"	221,000	5.87
1868	Jan.	220,000***	4.94
1901	Feb.	217,000	5.74
1904	Dec.	212,000	5.53
1911	Feb.	209,000	5.41
1872	"	206,000	5.08
1875	"	204,000	5.01
1872**	Mar.	200,000	4.89
1934	Jan.	195,000	4.40
1936	"	192,000	4.07
1935	Mar.	189,000	4.00
1935	Jan.	188,000	3.98
1935	Feb.	186,000	3.91
1936	"	185,000	3.77

* Taken from Tables 8 and 9 of Dept. of Transport Document No. 2.

** Also in Mar. 1895 and Feb. 1897.

*** Appears to be an error; probably meant to be 200,000

**** Appears to be an error; probably meant to be 7.52.

70. Table 8 shows the severest combination of lake levels and discharges which will prevail during the winter months (December thru March) under regulation Method No. 5. A plot of the December and January discharges and levels was made in order to determine the severest winter condition for the design of the ice cuts. This graph is also in the computation file of this office (Box D - 16) and is entitled "Monthly Mean Outflows of Lake Ontario for Dec. and Jan., 1860 - 1940, Method No. 5". An enveloping line through the lowest January points on this graph will give the severest January conditions. An enveloping line through the lowest December points will give the severest December conditions. From these lines the severest January 1st conditions, upon which the design of the ice cuts is to be based, was determined. See paragraphs 41d (2) and (3), Section IV.

71. Standard Low Water Profile. As previously stated (Par. 21 of Section II) a standard low water profile was prepared for use in any future model studies that may be made. This profile, together with a plan showing the stationing and location of gages, is shown on 8 drawigns, Plates 2 to 9 inclusive, of this appendix. The scale of this profile is 1" = 1,000' horizontal, and 1" = 4' vertical. Continuous stationing was laid out on the centerline of the main channel from Chimney Point to the foot of Cornwall Island. The stationing of secondary channels starts in each case at the upstream intersection with the main channel centerline and terminates at the downstream intersection. The stationing of objects on the shore line, such as gages, was determined by perpendicular projections to the centerlines.

72. Water levels were determined by a study of all existing data including surveys made by this office. The water level at principal points was determined from low water data given in the 1937 U. S. Lake Survey Report, from Canadian Department of Transport rating curves, and from rating curves constructed from data furnished by both the Department of Transport and the Hydro-Electric Power Commission of Ontario. The levels at intermediate points were determined from profile surveys made by the Canadians in 1919, 1920, and 1921, and by this office in 1941, by proportioning the losses between the main points in accordance with these profiles. Where water levels were available on both banks of a channel, separate profiles were shown for each bank.

73. Rating Curves at Important Gaging Stations in the International Rapids Section. Rating curves for the principal gaging stations were also constructed for use in connection with the model tests. These curves are shown on Plate 10 of this appendix. As previously stated, (par. 20 of section II) single line rating curves are applicable to this section of river since the changes in stage are very slow due to regulation of the lakes. All available Canadian and American data were used in the preparation of these curves.

GALOP ISLAND REACH AND GALOP CANAL

74. Galop Island Reach. The Galop Island reach extends from Chimney Point at the upper end of the International Rapids Section, to

the lower end of Lotus Island at the foot of Galop Rapids. Plates 1 and 1A of Appendix III - O(1) show this reach of river in detail, together with two possible plans of improvement. Plate 1 shows the plan recommended by this office and Plate 1A, a more expensive alternate plan.

75. The Galop Island reach has a length of about 6 miles, extending from about mile 68 to about mile 74 (navigation channel mileages). The total fall in this reach is about 10 feet. About a foot of this fall occurs in the part from Chimney Point to the head of Galop Island. About 7 feet of this fall occurs between the head of Galop Island and the head of Lalone Island. The remaining 2 feet occurs in the Lalone-Lotus Island part of the reach. The water level at the upper end of the reach is generally about El. 244 and that at the lower end, about El. 234. The flow past Galop Island is in the form of rapids, the north channel being called the Canadian Galop Rapids and the south channel, the American Galop Rapids.

76. An inspection of Plates 1 and 1A of Appendix III - O(1) will also show that the natural channels are very tortuous and the banks very irregular in this reach. Also velocities are very high. Navigation is at present carried past the Galop Rapids by the 14-foot Galop Canal and "North Channel" on the Canadian side of the river. Downbound traffic leaves the Galop Canal at Lock No. 28. Upbound traffic uses the canal all the way.

77. The head of Galop Island may be called the natural control of Lake Ontario. When this control is removed by the improvement plans, control will be taken over by Iroquois Dam. The water surface will then have very little slope through the Galop Island reach. The fall between Chimney Point and Lotus Island will be only a foot or two and water levels within the reach will vary between about El. 241 and El.247. In the upper part of the reach these levels are not much higher than present levels as may be seen by comparing the above elevations with those in paragraph 75. Reduction in velocities to meet navigation requirements, therefore, will have to be accomplished through deepening and widening. Also, islands will still remain above water and will have to be cut away in many places to obtain satisfactory alignment of the navigation channel. The extent to which these expedients are necessary may be seen on Plates 1 and 1A already referred to.

78. Original 238-242 Plan. Improvement of the Galop Island reach under the Original 238-242 Plan consisted of deepening the Galop Island south channel for navigation and providing additional discharge area through Galop Island in order to lower velocities in the navigation channel. A cut 500-foot wide through Galop Island was proposed in this plan. Other features of this plan included removal of Gut Dam between Adams and Galop Island and the removal of Locks Nos. 27 and 28 in order to increase the dischare capacity of the Galop Island north channel, the removal of Spenser Island Dike, channel enlargement in the vicinity of Lalone and Lotus Islands and opposite Chimney Island in order to reduce velocities in these reaches, and the construction of ice cribs across the various channels at the head of Galop Island in order to encourage the formation of an ice sheet above this point.

79. Plate M-II of the main report shows all the improvements proposed under the Original 238-242 Plan. Details of the plan are shown on five Canadian Department of Transport drawings, No. 2135. The cut through Galop Island is 500 feet wide and has a bottom grade of El. 216. All other cuts in the Galop Island reach have a bottom grade of El. 214, with the exception of the cut between Chimney Point and Chimney Island which has a bottom grade of El. 212. The navigation channel cuts in this reach have a minimum width of 600 feet. The cut in Lalone Island channel, is about 500 feet wide. The cut between Chimney Point and Chimney Island is about 1400 feet wide.

80. Since this plan was designed prior to creation of the present navigation velocity criterion the first computation that was undertaken by this office in connection with the design of the Galop Island reach was a check of the Original 238-242 Plan, to determine the maximum velocity which would prevail in the navigation channel with this plan. In accordance with criterion (3), Par. above, the maximum velocity should not exceed 4 feet per second for more than about 3% of the navigation season nor should it exceed about 4.5 feet per second at any time during the navigation season. The maximum discharge of 310,000 c.f.s. and a lake level of El. 246.5 were used in this check computation since this combination will result in the maximum velocity conditions (see Par. 41c (4) above). Using the backwater methods described in the preceding section, the following division of flow was obtained:

Galop Island		Lalone and Lotus Islands	
North Channel	68,000 c.f.s.	North Channel (Navigation)	260,000 c.f.s.
500' Cut	108,000 c.f.s	South Channel	50,000 c.f.s.
South Channel (Navigation)	134,000 c.f.s		
Total	310,000 c.f.s.	Total	310,000 c.f.s.

This division of flow may be compared with the results obtained by the Department of Transport for 300,000 c.f.s. and a lake level of El.247.5:

Galop Island		Lalone and Lotus Islands	
North Channel	76,000 c.f.s.	North Channel (Navigation)	262,000 c.f.s.
500' Cut	93,000 c.f.s.	South Channel	38,000 c.f.s.
South Channel (Navigation)	131,000 c.f.s.		
Total	300,000 c.f.s.	Total	300,000 c.f.s.

The flow through "North Channel" was computed as 25,000 c.f.s. for the 310,000 c.f.s. discharge condition. "North Channel" in quotation marks is used in this appendix to designate the present 14 - foot navigation canal between Dummond and Spencer Islands, so labeled on Plate 1 of Appendix III -0 (1), and should not be confused with north channels in general which are merely channels to the north of islands.

81. The maximum velocity in the navigation channel for the 310,000 c.f.s. discharge was computed as 5.4 feet per second by this office. This velocity occurred in a constricted section of the south channel near the lower end of Galop Island. It will be seen that this velocity is too high to satisfy the new criterion of 4.5 feet per second. The fall through the reach was computed as 3.3 feet, the water level at Chimney Point being approximately El. 244.3 and the water level below Lotus Island, about El. 241.0. These elevations agree with the backwater curves in Department of Transport Document No. 4, which should be the case since the computations were based on natural "n" values determined by this office and on average "n" values equivalent to the roughness factors used by the Canadians (see Table 6 above).

82. Recommended Plan. The above check of velocities in the Original 238-242 Plan showed that the design of this reach would have to be changed if it is to conform to the velocity requirement in the 1941 International Agreement. The cheapest method of lowering the velocity appeared to be to increase the cross section of the cut through Galop Island. Enlargement of the south channel would only tend to increase the quantity of flow in this channel and thus neutralize any attempt to lower velocities. Computations were therefore undertaken to determine the width of the cut through Galop Island required to lower the maximum velocity in the south channel to about 4.5 feet per second, the velocity agreed upon jointly be engineers of this office and engineers of the Canadian Department of Transport as fulfilling the requirement of the International Agreement, provided that a velocity of 4 feet per second be not exceeded more than about 3% of the time.

83. Various widths of cut were assumed and the corresponding divisions of flow and velocities were computed. After much cutting and trying, a width of 850 feet was arrived at as the width which results in the required reduction of velocity in the navigation channel. Plate 12, accompanying this appendix, shows a curve of maximum velocity vs. width of cut, which resulted in the determination of the 850 foot width. The following division of flow was found to prevail under this plan:

Galop Island	
North Channel	48,000 c.f.s.
850' Cut	150,000 c.f.s.
South Channel (Navigation)	112,000 c.f.s.
Total	310,000 c.f.s.

The division of flow for Lalone and Lotus Islands or the "North Channel" were not computed for this condition. The loss of head through the reach was found to be about 2.3 feet, the water level at Chimney Point being

about El. 244.3 and the level at Lotus Island about El. 242.0. The above value for loss is based on natural "n" values comparable to the roughness factors used by the Canadians (see Table 6 above).

84. A somewhat more detailed check of this plan was made in the Office, Chief of Engineers with the following results:

Galop Island		Lalone and Lotus Islands	
North Channel	67,000 c.f.s.	Galop Canal (est).	3,000 c.f.s.
850' Cut	119,000 c.f.s.	North Channel (Navigation)	274,000 c.f.s.
South Channel (Navigation)	124,000 c.f.s.	South Channel	33,000 c.f.s.
Total	310,000 c.f.s.	Total	310,000 c.f.s.

The flow in the "North Channel" was computed as 15,000 c.f.s. The total drop through the reach was found to be about 1.55 feet, the water level at Chimney Point being about El. 244.3 and the level below Lotus Island about El. 242.75. As explained in the preceding section (Par. 51 above), this office used "n" values varying between .020 for regular cuts to .025 for unimproved natural channels together with expansion losses of .50 Δhv. These roughness factors being generally lower than the natural "n" values computed by this office or those computed by the Canadians a flatter slope would naturally be expected. The difference in division of flow obtained is due entirely to differences in methods of computation. A model study should be helpful in determining the correct answer.

85. The maximum velocity in the navigation channel according to the computations made in the Office, Chief of Engineers, was found to be about 4.67 feet per second at a point near the lower end of Galop Island. At all other points in the navigation channel the velocity was below 4.5 feet per second. The maximum velocity in the Galop Island cut was found to be about 4.75 feet per second at the lower end of the cut.

86. An idea of the effect of the various cuts on the distribution of flow may be obtained by a comparison of the above figures with the natural distribution of flow as measured by the Hydro-Electric Power Commission of Ontario. The following are average percentages of flow in the Galop Island reach as computed by this office from the H.E.P.C. discharge measurements and the division of flow for a total river discharge of 310,000 c.f.s. obtained by applying the computed percentages.

Galop Island		Lalone and Lotus Islands	
North Channel(50.4%)	156,000 c.f.s.	North Channel(90.9%)	282,000 c.f.s.
South Channel(49.6%)	154,000 c.f.s.	South Channel(9.1%)	28,000 c.f.s.
Total	310,000 c.f.s.		310,000 c.f.s.

87. The cuts used in the computations of the Recommended Plan were identical with those in the Original 238-242 Plan with two exceptions. As already stated, the Galop Island cut was made wider. The other difference was in the width of the Lalone and Lotus Island north channel. This cut was made about 450 feet wider at the narrowest point directly opposite the town of Cardinal before the computations were begun because it could be determined in advance that this cut would be too small to satisfy the velocity criterion of 4.5 feet per second. The extra width was provided on the south side of the Channel, cutting more deeply into Lalone and Lotus Islands.

88. After it was determined that the maximum velocity condition was satisfied, a study was made to determine what percentage of time a velocity of 4 feet per second would be exceeded in the navigation channel with the 850-foot wide Galop Island cut. In this study use was made of the graph entitled "St. Lawrence River Discharge - Method No. 5, From 1860 to 1939, Months of April through November of each year only", on which graph the 638 monthly average discharges of the St. Lawrence River were plotted against monthly-average Lake Ontario levels. This graph is in the computation files of this office (Box D-16). Computations were made to determine a line on this graph which would represent a navigation channel velocity of 4 feet per second. In making this computation, however, the Alternate Plan was used instead of the Recommended Plan. The Alternate Plan has a 1600-foot wide cut through Galop Island designed for navigation, with no improvement in Galop Island south channel. It will be seen later that the Alternate Plan is comparable to the Recommended Plan as far as maximum navigation channel velocities are concerned (par 113 below). It has been assumed, therefore, that the computations based on the Alternate Plan will apply equally well to the Recommended Plan.

89. The method of determining the 4-foot per second line on the above graph was rather indirect. When these computations were made an 1800-foot wide Galop Island cut was being considered. Therefore the original computations for frequency were based on this width. Several flows and lake levels were assumed and the corresponding maximum velocity in the navigation channel computed for each. These values were plotted on the graph and lines of equal velocity drawn. Then in order to determine the 4-foot per second line for the 1600-foot width of cut, one point on this line was computed and a line parallel to the others was drawn. This line is marked "4' per second with 1600' channel" on the graph.

90. Having determined the line representing 4 feet per second, it was obvious that all plotted points below this line (representing lower lake levels) would give higher velocities than 4 feet per second. The number of points below this line was determined. This represented the number of months in the total of 638 navigation months that a velocity of 4 feet per second would be exceeded. Dividing this number by 638 would give the portion of time during the navigation season that a 4-foot per second velocity would be exceeded. The number of plotted points below the line was 21. The percentage is therefore 3.3%, which fulfills the requirement that the percentage shall not exceed about 3%. Approximately the same result was obtained by plotting the results in curve

form, as may be seen on Plate 13 of this appendix. The curve showed 23 points instead of 21 as determined above.

91. Under the discussion of Criterion e in Section IV, the adequacy of the channel cuts in this reach to satisfy the criterion of no raising of Lake Ontario levels was discussed (par 41 e (3). It was shown that a certain variation in pool levels at Long Sault Dam is required in order to satisfy this criterion. This required variation is not unreasonable however. In the case of the Recommended Plan a variation from El. 235.0 to El. 242.7 is required, with a minimum of El. 238.2 for open river conditions.

92. It was also pointed out, discussion of Criterion f in Section IV, (paragraph 41 f (2) that the larger the cuts in the Galop Island reach, the higher the power pool can be maintained at Long Sault Dam and still not effect lake levels. The subject of power benefits therefore enters into the design of the Galop Island reach. Backwater computations were made to determine for the various plans of improvement proposed for the Galop Island reach, maximum pool levels which can be maintained at Long Sault Dam (or the Barnhart Island powerhouse) and not to interfere with Lake Ontario levels. The results of this study are shown on Table 9 of this appendix.

TABLE 9

Effect of Improvements in Galop Island Reach on Headwater Levels at Barnhart Island Powerhouse

Method No. 5 Condition	Lake Ontario Elev.	Flow (1000 cfs)	W.S. Elev. at Lotus Island: Orig. 238-242	W.S. Elev. at Lotus Island: Orig.* 238-242 Plan (adj)	W.S. Elev. at Lotus Island: Rec. Plan	W.S. Elev. at Lotus Island: Alt. Plan	W.S. Elev. at Powerhouse**: Orig. 238-242 Plan	W.S. Elev. at Powerhouse**: Orig.* 238-242 Plan (adj)	W.S. Elev. at Powerhouse**: Rec. Plan	W.S. Elev. at Powerhouse**: Alt. Plan	Saving in Power Head: Rec. over Orig. (adj)	Saving in Power Head: Alt. over Orig. (adj)	Saving in Power Head: Alt. over Rec.
Ice Cover (Winter) Conditions													
1. Min. Lake Level (Min. flow)	243.77	185	239.0	239.6	240.6	240.7	231.5	232.9	235.1	235.5	2.2	2.6	.4
2. Min. Headwater at Powerhouse	244.07	192	239.2	239.8	240.8	241.0	231.0	232.5	235:0	235.3	2.5	2.8	.3
Open River (Summer) Conditions													
3. Min. Lake Level (Min. flow)	244.03	180	241.8	242.1	242.5	242.6	240.3	240.6	241.0	241.1	.4	.5	.1
4. Max. Headwater at Powerhouse	245.89	200	244.0	244.3	244.4	244.5	242.2	242.5	242.7	242.8	.2	.3	.1
5. Min. Lake Level at max. flow	246.78	310	241.6	242.4	243.1	243.5	235.5	237.0	238.2	238.6	1.2	1.6	.4
6. Max. Lake Level at max. flow	249.10	310	245.4	245.9	246.0	246.3	241.4	242.0	242.3	242.5	.3	.5	.2

* Figures in this column adjusted to "n" values used by this office in the computation of the recommended and Alternate Plans.

** Assuming all gates in Iroquois Dam wide open and limitation on pool levels removed by International Commission.

93. Six discharge conditions are shown in Table 9. These are the six critical discharge conditions shown in profile on Plate 11 of this appendix. The profiles, however, show only the conditions which will prevail under the Original 238-242 Plan. The table shows the conditions for all three plans considered in this report, the Original 238-242 Plan and the two plans prepared by this office.

94. The figures in Table 9 have been obtained from the gage relation curves in Department of Transport Document No. 4 with appropriate adjustments for the differences in losses in the Galop Island reach under the various plans of improvement proposed. The columns marked "Original 238-242 Plan" were obtained directly from the backwater curves in Document No. 4. The columns marked "Original 238-242 Plan (adj.)" were obtained by reducing the loss through the Galop Island reach (from Butternut Island to below Lotus Island) in accordance with the ratio of the squares of the effective "n" values used by the Canadians and this office for the Galop Island south channel, $\frac{(.029)^2}{(.034)}$. The columns marked "Recommended Plan" were obtained by making the loss between the above two points, 1.2 feet for 310,000 c.f.s. and the losses for lesser flows proportional to the squares of the discharges. The loss for Condition 6 was reduced still further by dividing by 1.2 to take care of the higher water surface prevailing under this condition. The columns marked "Alternate Plan" were obtained by making the loss between the above two points, 0.9 feet for 310,000 c.f.s. and the losses for lesser flows proportional to the squares of the discharges. The figures in the last line were furthere corrected by the 1.2 factor as before. The figures in the last three columns were obtained by subtraction.

95. The last three columns show the saving in power head accomplished by the various plans. It will be seen that the larger Galop cuts in the Recommended and Alternate Plans result in savings in power head from 0.2 of a foot to 2.8 feet over the Original 238-242 Plan, depending on the condition of flow. The critical condition is the first one shown, as this condition will determine the prime power available. The Recommended and Alternate Plans will provide 2.2 feet and 2.6 feet of additional power head, respectively, over the Original 238-242 Plan for this condition of flow. It must be emphasised that only a portion of these power benefits will be obtained as long as the maximum elevation of the Barnhart Island pool is restricted to 238 under the provisions of Article IV, paragraph (e) of the International Agreement of March 19, 1941.

96. After the computations for the Recommended Plan were completed, it was decided to change the alignment of the navigation channel in order to make navigation of this reach easier. The change in alignment may be seen by comparing Plates M-I and M-II of the main report, or comparing Sheet I of Canadian drawings Nos. 2136 with Plate 1 of Appendix III-O(1). It will be seen that the change was made in the lower end, principally in the Dead Man Rapids area, where the navigation channel goes through a reverse curve in switching from the Galop Island south channel to the Lalone Island north channel. The southeast corner of Galop Island was cut off and the cut through Lalone Island increased. Minimum areas were

not affected, however, thus leaving velocity conditions practically the same as previously computed. This new alignment reduces the total angle of curvature in the lower end of the Galop reach from about 95° to about 48°.

97. Consideration was also given to easing the curvature of the navigation channel at the upper end of the Galop Island reach between Chimney Point and Chimney Island, but it was decided not to change this alignment at the present time. Since it is intended eventually to make a model study of the Galop Island reach, the necessity for this change can be determined at that time.

98. Some thought was also given to deepening the 850-foot cut through Galop Island so that this channel would also be available for navigation in the future if it should ever be desired. The bottom grade now proposed is El. 216 through the island itself and downstream from the island and El. 220 from the head of the island to deep water opposite Butternut Island. If this grade were made El. 214 throughout and the flare of the upper entrance widened slightly, this channel could be used for navigation. It might also prove desirable in the future in order to increase the usability of this channel for navigation to make an additional cut through the bar between Chimney and Drummond Islands, thus providing a straight alternate channel all the way through the rapids section. This idea was not incorporated in the Recommended Plan, however, because of the additional cost involved and the uncertainty as to the suitability of this channel for navigation. The proposed model study is also expected to throw some light on this subject. If currents and velocities are found suitable for navigation, the above idea should be given consideration in the development of the final plan.

99. The minimum water levels in this reach during the navigation season were also computed assuming improvement in accordance with the Recommended Plan, as a check on the project grade of El. 214. Levels for several flows were computed but the water levels for the minimum flow of 180,000 c.f.s. were found to be the lowest - El. 242.9 at Chimney Point and El. 242.4 at Lotus Island. The grade of El. 214, therefore, more than satisfies the requirement of 27-foot depth. The drop through the Galop Island reach as computed by the Office, Chief of Engineers, was used in these computations, together with the backwater curves in Canadian Document No. 4.

100. Alternate Plan. An Alternate Plan was prepared for the Galop Island reach which, although more expensive, is considered more satisfactory from the standpoint of navigability. This plan was developed for possible use in case the model study should show the Recommended Plan to be undesirable hydraulically. As may be seen by an inspection of Plate 1 of Appendix III-C (1), the alignment of the navigation channel through the Galop Island Reach is none too straight. It was thought that difficulties might develop in navigating the bends with velocities of 4.5 feet per second. The presence of fog would also increase these difficulties. It was thought that a wider and straighter channel in this high-velocity reach would have decided advantages from

the standpoint of safe navigation. As has already been mentioned, the tendency in the Great Lakes is to provide wider and straighter channels to make for more efficient and safe navigation. This alternate plan for the Galop Island reach is shown on Plate M-1A of the main report and, in more detail, on Plate 1-A of Appendix III-O (1).

101. The principal objective, in preparing the Alternate Plan, was to provide as straight a navigation channel as possible through the Galop Island reach without getting into unnecessarily deep cuts and without entailing too much rock excavation. Subsurface explorations had shown that the rock surface rises rapidly in the south half of Galop Island. Therefore, it was desirable to locate the channel through Galop Island as far north as possible. Very little rock was encountered elsewhere in the Galop Island reach. The remainder of the channel therefore, followed deep water as nearly as possible. The depth of the channel was made the same as the navigation channel of the Recommended Plan with a bottom grade of El. 214. The 1600-foot width of the channel was determined by hydraulic computations, being the width necessary to lower maximum velocities in the navigation channel to about 4.5 feet per second.

102. Before deciding upon a definite plan upon which to make detailed hydraulic computations, a general study of current directions was made. It appeared that there might be undesirable cross currents at certain places in this channel. Without any dikes, it appeared that there would be a tendency for the main body of the flow to continue to follow the deep natural channel south of Chimney Island and across in front of Butternut Island, into the Galop Island north channel, thus producing a decided cross current at the upper entrance to the Galop Island cut. Likewise, it appeared that there would still be a strong tendency for a large flow to pass from south to north between Galop and Lalone Islands, thus producing bad entrance conditions at the lower end of the Galop Island cut. Also the flow from the Galop Island north channel would be entering the main channel at a sharp angle at the lower end of the Galop Island cut.

103. The best way to eliminate these undesirable currents appeared to be to close off the side channels with dikes and completely confine the navigation channel. This could be done without much additonal expense by utilizing the spoil from the channel cuts. On the north side complete confinement was possible from Chimney Island to below Baycraft Island; on the south side, from Chimney Island to below Lotus Island, the full length of the reach. The opening of the north side below Baycraft Island was necessary in order to provide an outlet for the Galop Island north channel. The little flow that can get into this channel at the upper end with the dikes in place should not be noticeable at this junction point. The recommended dike locations are shown on Plate 1A of Appendix III-O(1).

104. The dikes parallelling the main navigation channel also serve another very important function, besides preventing cross currents. They increase the friction loss in the navigation channel and cause more flow to take the outside channels. This has the effect of lowering velo-

cities in the navigation channel and permitting the use of a smaller cut through Galop Island. The dikes will also be an aid to navigation in foggy weather, helping to outline the channel.

105. It is proposed to make a model study of this plan also, to check the many assumptions made above. Some of the dikes may be found unnecessary, for instance, Dike No. 5 between Chimney and Butternut Islands. In the model it will be possible to study the effects of the various dikes on navigation currents and thus determine their necessity.

106. As in the case of the Recommended Plan, several cut and try backwater computations, assuming various widths of cut through Galop Island, were necessary to determine the final width of cut required to keep the maximum velocity in the navigation channel within the established criteria. The method used by this office in these computations was the check method described in Par. 51 of the preceding section. A roughness factor of .020 was used for the entire navigation canal from Chimney Island to the lower end of the confined canal at Baycraft Island, together with an expansion loss of $.50\Delta h_v$. A roughness factor of .025 was used for all other channels except the "North Channel" where the regular cut value, .020, was used. An expansion loss of $.35\Delta h_v$ was used along with the .025 value of "n". Balancing the flows was simpler in this case because the dikes definitely defined the channels and there were only three channels to consider.

107. As in the preceding case, the results of the various trial widths were plotted in graph form (Plate 14 herewith). The maximum velocity in the Galop Island cut was plotted against the cut width assumed in each case and the width of cut which would give a maximum velocity of 4.5 feet per second determined from this curve. A cut width of 1600 feet was required to meet this criterion. The division of flow for this width was found to be as follows;

Galop Island		Lalone and Lotus Islands	
North Channel	25,000 c.f.s.	North Channel(Navigation)	282,000 c.f.s.
1600' Cut (Navigation)	225,000 c.f.s.	South Channel	28,000 c.f.s.
South Channel	60,000 c.f.s.		
Total	310,000 c.f.s.	Total	310,000 c.f.s.

108. The flow through the "North Channel" in this case is, of course, equal to 25,000 c.f.s., the flow through Galop Island north channel. It will be noted that the flow through Galop Island south channel is not equal to the flow in the Lalone and Lotus Island south channel. The reason for this is that when these computations were made Dike No. 2, between Lalone and Baycraft Islands, was not in the plan and flow could pass from the south channel to the north channel at this point.

109. The head loss through the reach was found to be about 1.0 foot, the water level at Chimney Point being about El. 244.3 and that below Lotus Island about El. 243.3. It will be noted that this value of drop is quite low compared to the loss obtained by this office for the Recommended Plan (see Par. 83 above). This difference resulted from the use of lower "n" values. Assumed "n" values and energy losses obtained from a study of the Toussaints Island reach were used in this case, instead of the natural "n's" and losses used in the computations of the Recommended Plan.

110. Check computations made in the Office, Chief of Engineers using the same methods as in the Recommended Plan (see Par. 84) resulted in the following division of flow:

Galop Island		Lalone and Lotus Islands	
North Channel	22,000 c.f.s.	North Channel (Navigation)	252,000 c.f.s.
1600' Cut(Navigation)	230,000 c.f.s.	South Channel	58,000 c.f.s.
South Channel	58,000 c.f.s.		
Total	310,000 c.f.s.	Total	310,000 c.f.s.

It will be noted in this case that the flow through the Galop Island south channel does equal the flow through the Lalone and Lotus Island south channel, Dike No. 2 being included in these computations. As before, the flow through "North Channel" will be the same as the flow in the Galop Island north channel -- 22,000 c.f.s.

111. The head loss was determined as 1.25 feet, the water level at Chimney Point being about El. 244.3 and the level below Lotus Island about El. 243.05. It will be noted that this loss is consistent with the 1.55 feet obtained for the Recommended Plan, since the cut in this case is larger. This is as it should be since identical methods were used in the computations. The maximum velocity in the navigation channel occurred in the 1600-foot cut through Dixon Island where a velocity of 4.75 feet per second was found to prevail. The maximum velocity in the Galop Island cut was found to be about 4.69 feet per second and the maximum velocity in the cut between Chimney and Drummond Islands was found to be about 4.62 feet per second. All other maximum velocities were below 4.5 feet per second.

112. Since the computations of the Office, Chief of Engineers are based on the actual Recommended and Alternate plans shown on plates 1 and 1A of Appendix III-C-(1) and since the computation methods of that office were identical for the two plans it is suggested that they be accepted in preference to the earlier computations of this office which were not based on the exact plans shown and wherein different methods of computation were used for the two plans. It must be kept in mind however that none of the results can be considered exact because of the many assumptions which had to be made in the computations. The proposed

model study of this reach is expected to throw more light on this subject.

113. A comparison of the maximum velocities obtained for the two plans prepared by this office shows that the plans are essentially alternates as far as velocities are concerned. The maximum navigation channel velocity in the case of the Recommended Plan was found to be 4.67 feet per second and in the case of the Alternate Plan, 4.75 feet per second. By a small amount of additional excavation in each case these velocities can both be lowered to 4.5 feet per second, if desired. It was not considered necessary to go to this refinement in design at the present time, however, because the results of the model study are not yet known. Velocities in excess of 4.5 feet per second occur at only one place in the Recommended Plan, at a constricted point in the Galop Island south channel. The maximum velocity in the Alternate Plan occurs in the Dixon Island cut. The velocity in Galop Island cut also exceeds 4.5 feet per second in the Alternate Plan, being 4.69 feet per second. The velocity just upstream from Drummond Island in the Alternate Plan may also be slightly higher than 4.5 feet per second. The velocity computed at this point was 4.62 feet per second.

114. As mentioned under the Recommended Plan (Par. 88), a study was also made of the Alternate Plan to determine the frequency of occurrence of velocities greater than 4 feet per second. This study showed that a velocity of 4 feet per second would be exceeded about 3.3% of the navigation season. An 1800-foot wide cut was actually used in these computations, as previously stated, and the results later converted to the 1600-foot width. The study of the 1800-foot width cut showed the maximum velocity for this width of cut to be about 4.0 feet per second instead of the 4.5 feet per second indicated for the 1600-foot channel.

115. Since the Alternate Plan has less slope through the Galop Island reach than the Recommended Plan, it is obvious that Lake Ontario levels will not be affected by this plan any more than by the Recommended Plan (see Par. 111 above).

116. Also, as pointed out under the discussion of the Recommended Plan (Par. 92), the larger cuts of the Alternate Plan will result in a small saving in power head at the Barnhart Island powerhouse over the Recommended Plan. This saving is small, however, varying from only .1 to .4 of a foot depending upon the discharge conditions of the river. Table 9 contains the detailed figures upon which this statement is based.

117. Treatment of Galop Canal. In the Recommended Plan, it is proposed to remove Locks 27 and 28 in order to increase the discharge capacity of the Galop Island north channel. There will no longer be any need for the locks, inasmuch as river slopes will be so flat and depths so great that 14-foot navigation will be able to use the canal if desired without the necessity of lockages.

118. In the Alternate Plan, so little water will flow through

the Galop Island north channel that the additional discharge capacity of the Galop Canal would not be noticed in reduced velocities in the navigation channel. Therefore, in this plan, the locks have been left in place.

119. The only effects that construction of the project will have on the existing Galop Canal will be the following:

- a. The construction of Iroquois Dam will prevent downbound navigation from using the river downstream from Lock 28. Traffic will be confined to the canal from the completion of the first stage of construction to the time when the new Point Rockway Canal becomes usable.

- b. If too much of the cut at Point Three Points is made prior to raising the pool at Long Sault Dam to El. 225, there is danger that there will not be water enough over the lower sill at Lock 25.

120. A backwater study was made to check the second point above. Two plates were prepared (Plates 15 and 16 herewith) showing backwater up to Lock 25, one assuming the Point Three Points cut to be made and the other with no improvement at Point Three Points. Inspection of the plates will show that the backwater curve drops below the standard low water profile with the cut completed. The actual water surface may be even lower than that shown on the profile due to inaccuracies in computation. The lower sill of Lock 25 is 16 feet below low water. Since the ruling depth in the St. Lawrence canals is 14 feet at low water, a lowering of 2 feet at this point is permissible. Prior to the raising of the Barnhart Island pool to 225, excavation in the Point Three Points cuts must be limited to the amount which will not cause a lowering in excess of 2 feet at Lock 25.

121. In the Original 238-242 Plan (Plate M-II of the main report) it was proposed to cut away the dike of the Galop Canal in two other places in order to provide access to and from the 14-foot canal. One of the points is opposite Sparrowhawk Point and the other opposite the lower end of Toussaints Island. The grade of these cuts was to be El. 225.

TOUSSAINTS ISLAND REACH

122. This reach extends from Lotus Island to Iroquois Point, a distance of about four miles - from about Mile 74 to Mile 78. This reach is shown in detail on Plates 2 and 3 of Appendix III-O(1). It will be noted that it consists of a single channel, except for a relatively small island, Toussaints Island, in the middle of the reach. The water surface slope under natural conditions is fairly flat. The water level at the upper end under present conditions is about El. 234 and at the lower end about El.230. Most of this drop occurs in a constricted "S" shaped bend at Sparrowhawk Point. Above and below the bend the water

surface takes a more gentle slope. At the lower end of the reach, Iroquois Point, there is another constricted "S" shaped bend where the water surface again steepens. The Hydro-Electric Power Commission of Ontario has made discharge measurements in this reach and finds that only about 9% of the total river discharge flows to the north of Toussaints Island under natural conditions.

123. The 14-foot Galop Canal also parallels the river in this reach, terminating just below the constricted section at Iroquois Point. Lock 25 is at the lower end of the canal. At present there are no connections between the river and the canal in this reach. As stated above in connection with the Galop Island reach, this part of the canal is used mostly by upbound traffic, while downbound traffic generally uses the open river.

124. The plan of improvement in this reach follows very closely the Original 238-242 Plan, shown on Plate M-II of the main report. A control dam is proposed at the lower end of the reach at Iroquois Point, to control the levels and outflows of Lake Ontario. The water level after improvement will range from about El. 240 to about El. 246. The new navigation channel will follow generally through the middle of the river channel and enter the proposed Point Rockway Canal just to the south of the control dam. The only channel improvement necessary will be at the constricted section at Sparrowhawk Point and Toussaints Island in the center of the reach. Velocities elsewhere are satisfactory for both navigation and ice cover conditions with the raised pool level, being less than 4.5 feet per second during the navigation season and less than 2.25 feet per second on January 1st of every year. Channel depths and widths are also adequate for navigation except at this one constricted section.

125. The problem of providing a satisfactory navigation channel at the constricted section will be a difficult one. The "S" curve in the natural channel will undoubtedly produce undesirable cross currents, regardless of the alignment of navigation channel selected. For this reason, it is expected that the final design of the channel cuts in this reach will have to be based on model tests. The channel cuts shown on Plate 2 of Appendix III-O(1) represent the best judgment of this office as to what may prove to be a satisfactory solution at this point.

126. Several plans of improvement at this point were studied before the one shown (Plan A) was selected, as follows:

a. <u>Plan A.</u>

(1) This is the recommended plan shown on Plate 2 of appendix III-O(1). It will be noted that this plan consists of a deep cut (grade El. 205) through Sparrowhawk Point and a shallower cut (grade El. 213) off the south side of Toussaints Island. A bottom grade of El. 213 is considered sufficient for 27-foot navigation inasmuch as low water during the navigation season will be about El. 242 at this point. (El. 242.4 computed for Lotus Island and El. 241.75 for Iroquis Dam.)

Low water during the winter will be about El. 240, but low water on January 1st will be only about El. 243. The above cuts are sufficiently large to limit the average velocity to 2.25 feet per second with a flow of 220,000 c.f.s. and a water surface of El. 242 (see Par. 41 d (2) of Section IV).

(2) At Sparrowhawk Point, it proved more economical to provide a deep cut 1,000 feet wide than a wide cut with only the depth required for navigation. The deep cut is also considered desirable at this point, in order to draw a large volume of water through the cut and so help to straighten navigation currents. A cut narrower than 1,000 feet was considered less desirable from the standpoint of safe navigation.

(3) The cut on the south side of Toussaints Island was for the twofold purpose of providing a straight course for navigation and easing the curvature of the flow at this point. The small cut at the tip of Sparrowhawk Point was also for the purpose of reducing the cross-current flow. The Toussaints Island cut has been carried all the way out to deep water in order to allow plenty of space for maneuvering through the cross currents.

b. Plan A-1. This plan has the same Toussaints Island cut as Plan A. The cut as Sparrowhawk Point is identical with that in Plan B described below, that is, the tip of the point is cut off instead of the cut being made through the point. This plan is considered to be as satisfactory as Plan A, inasmuch as an equally straight navigation channel alignment can be obtained and hydraulic conditions are expected to be no worse. This plan involves more dredging, however.

c. Plan B. This plan develops the Toussaints Island north channel and the main channel at Sparrowhawk Point. It would appear that this plan might eliminate most of the trouble due to cross currents. The alignment of the navigation channel is not as good, however, and velocities in the north channel may be higher due to the direct approach of the water from above. This plan is also more costly than Plan A.

d. Plan C. This plan is similar to the Original 238-242 Plan shown on Plate M-II of the main report and on Sheet I of Department of Transport Draw-

ings No. 2136. In this plan, a 900-foot wide cut at grade El. 206 is provided through Toussaints Island and the tip of Sparrowhawk Point is cut off to grade El. 205. It differs from the Original 238-242 Plan in that improvement of the north Toussaints Island channel has been eliminated and the cut through the island widened. This plan is cheaper than Plan B but more expensive than Plan A. It does not appear to have any advantages over Plan A.

127. As stated above, it is the intention of this office that selection of the final plan for this reach shall be based on model tests. The problem is largely one of current directions and cannot be solved in any way except by a model. The cut areas have been made sufficiently large to reduce velocities on January 1st below 2.25 feet per second. Other than this, it cannot be stated with any degree of assurance that the plan is satisfactory.

128. Entrance conditions at the upper end of the Point Rockway Canal will also have to be studied in a model. If the model used to study the Toussaints Island problem is not large enough for this purpose, a larger model of the area around the control dam will have to be built. Operation of gates in the dam may have a decided effect on the approach condition at the entrance to the canal. Also, the shape of the excavation at the entrance may have to be changed, or even the location of the entrance itself.

129. The area through the Iroquois Dam with a water level of El. 242 will be about 84,000 square feet with all gates open. There are forty gates, in the dam each 50 feet wide, with sills at El. 200. With a flow of 220,000 c.f.s. on January 1st, the velocity through the dam will be higher than 2.25 feet per second. However, by allowing the gates to project into the water it is expected that the surface velocity can be lowered sufficiently to start the formation of an ice sheet. Also, a few feet upstream from the dam the area will be larger and the velocity lower.

POINT THREE POINTS REACH.

130. This reach extends from Iroquois Point (about Mile 78) to the lower end of the Point Rockway Canal (about Mile 80.5). For three quarters of a mile or so below the Iroquois Dam the river flows through a narrow constricted section where the water surface slope is steep. Below this point the river widens out and the slope of the water surface is more gentle. At the lower end of the reach, opposite Point Three Points, the river narrows down again and the slope is somewhat steeper. The water surface fall through the first three quarters of a mile is about 3.5. feet. The remainder of the fall is about 2 feet, making a total of 5.5 feet for the reach. The water surface at the upper end is generally about El. 230 and at the lower end about El. 225.5.

131. Under improved conditions the water level will vary from about El. 239 to About El. 245. The lowest water level on January 1st will be about El. 240. The cuts in this reach were designed for the ice formation criterion of 2.25 feet per second with a flow of 220,000 c.f.s. and a water level of El. 241 (see Par. 41d (2) of Section IV). Since navigation will use the Point Rockway Canal in this reach, the criterion for maximum navigation channel velocity did not have to be applied.

132. Enlargement of the constriction at the upper end of the reach just below Iroquois Dam to satisfy the ice criterion was not considered warranted due to its excessive cost and the fact that turbulence from the dam might keep the water from freezing even if the channel were enlarged. Enlargement was considered practicable, however, at all places where excessive velocities would occur between Point Rockway and the Barnhart Island powerhouse. The middle portion of the reach from Point Rockway to Point Three Points is already large enough to satisfy the ice criterion. At Point Three Points, however, an additional cross-sectional area of about 40,000 square feet will have to be provided.

133. Several plans for the Point Three Points cuts were studied, as follows:

a. Plan A. In this plan all of the cut was made on the Canadian side.

b. Plan B. In this plan all of the cut was made on the American side.

c. Plan C. This is the plan shown on Plate 4 of Appendix III-O(1) and provides for cuts on both sides of the river. This plan is similar to the Original 238-242 Plan shown on Plate M-II of the main report.

Plans A and B have less total excavation than Plan C. Plan A, however, involves a large quantity of dry cut. Plan B, which has the least excavation of all three plans, carries with it a difficult spoil problem. Plan C was selected as being the one which would probably cost the least and the one which would be most suited to the Point Rockway Canal entrance just downstream from the cut.

OGDEN ISLAND REACH AND MORRISBURG CANAL

134. The Ogden Island reach extends from the lower end of the proposed Point Rockway Canal at Point Three Points (about Mile 80.5) to Canada Island (about Mile 85). Canada Island is the downstream limit of channel improvement work in the pool of Long Sault Dam. Below this point ample depth and width are available for a satisfactory navigation channel and enough area is available to keep velocities on January 1st below 2.25 feet per second. Extensive channel work, however, is necessary in the Ogden Island reach as is shown on Plate 4 of Appendix III-O(1).

135. Water levels in this reach average from about El. 224.5 at the upper end to about El. 212 at the lower end under present river conditions - a fall of 12.5 feet in the 4.5 miles. The slope is fairly flat for the first mile and one-half to the upper end of Ogden Island and 14-foot navigation uses the main river channel for this distance. The fall in this part is only about a foot. The slope is steep from the head of Ogden Island to Canada Island, the fall in this section being about 11.5 feet. The Morrisburg Canal on the Canadian side of the river by-passes this steep section. Lock 24 is at the upper end of the canal and Lock 23 at the lower end. The north channel is the main river channel in this reach. The south channel carries very little flow. Measurements by the Hydro-Electric Power Commission of Ontario show that only one or two percent of the total river flow is carried by the south channel under present conditions. Since the north channel carries practically all of the flow and is rather narrow, velocities in this channel are quite high and the flow in some parts is in the form of rapids. The "Rapide Plat" is in the upper end of the north channel. The south channel is known as "Little River". Most of the fall in the south channel occurs at Waddington, where a causeway and the ruins of an old dam obstruct the channel.

136. "Under improved conditions, the pool level in this reach will range from about El. 237 to about El. 244. The lowest water level during the navigation season will be about El. 238.5 during the trial period when the pool at Long Sault Dam is limited to El. 238. After a pool level of El. 242 is permitted, the minimum navigation season level will be about El. 241. The lowest level on January 1st will be about El. 239. As in the preceding case, the cuts in this reach were designed for the ice criterion of 2.25 feet per second with a flow of 220,000 c.f.s. and a water level of El. 241 (see Par. 41d (2) of Section IV). Perhaps it should be mentioned at this point, since there is no section of this appendix devoted to the Long Sault Canal, that the minimum navigation season water level at the Long Sault Dam will be about El. 237."

137. The cut at Leishman's Point was made for a twofold purpose of providing additional cross-sectional area to lower velocities to 2.25 feet per second and to provide a better entrance condition for the improved Ogden Island south channel. The bottom grade was made El. 210 so that navigation could use that part of the channel if desired. A cut could have been made through Leishman's Point, as was done at Sparrowhawk Point, but this was considered less desirable because of the possibility of producing adverse currents at the downstream entrance to the Point Rockway Canal. It was also thought that there would be less rock cut in the outer portion of the point and that the spoil problem would be simpler. Another alternative would have been to cut away some of the Canadian shore opposite Leishman's Point. This solution would not have been as good a solution hydraulically, however, because the entrance to the south channel would not have benefited. It will be noted on Plate M-II of the main report that all three schemes were incorporated in the Original 238-242 Plan. This office did not consider any additional excavation over that shown on Plate 4 of Appendix III-O(1) to be necessary since the required hydraulic area is provided with the single cut.

138. Several plans for the improvement of the Ogden Island section were studied. The plan finally chosen is that shown on Plate 4 of Appendix III-O(1). The north channel is developed for 71,000 sq. ft. of cross-sectional area; the south channel, for 27,000 sq. ft.; all areas being based on a water level of El. 241, as mentioned above. The January 1st discharge of 220,000 c.f.s. divided by the total area, 98,000 sq. ft. gives a velocity of 2.25 feet per second. The determining factor in the amount of area provided in the north channel was the alignment of the navigation channel. The Morrisburg Canal dike was first assumed removed to El. 208 as was this the most economical way to obtain additional discharge area. The navigation channel was then laid out and the desired clearances provided at the three projections on the north side of the island. With a bottom grade of El. 210, which was necessary for navigation, the approximate resulting minimum area was about 71,000 sq. ft. The south channel was then enlarged to 27,000 sq. ft. to make up the total of 98,000 sq.ft. If further relief of velocities in the navigation channel is required, the south channel can be further developed to 37,000 sq. ft. by a small amount of excavation in the constricted sections.

139. The cut through Canada Island is necessary for the sole purpose of providing a straight navigation channel. A cut 600 feet wide at navigation grade (El. 210) is proposed.

140. Inspection of Plate M-II of the main report will show that in the Original 238-242 Plan a cut was also provided through the middle of Ogden Island. It is the opinion of this office, however, that such a cut is not economical. If the north channel improvement downstream from this cut could be eliminated by the cut, the cut would be economical. But such is not the case. Improvement of the north channel is necessary to obtain a satisfactory alignment of the navigation channel.

141. Detailed backwater computations were not made in connection with the design of the ice cuts. The division of flow between the north and south channels was assumed to be proportional to the discharge areas. It is obvious that the velocity in the larger channel will be greater than the overall average velocity. This method of design was considered satisfactory, however, in view of the possibility that model tests will eventually be made of this reach and the actual velocities in each channel will be determined. Model studies of this reach are desirable primarily for the purpose of studying navigation channel currents and determining the most desirable shapes of the many channel cuts as they affect these currents.

142. In connection with the Point Three Points improvement, it was pointed out that the cuts in that reach should not be completed until the pool at Long Sault Dam is raised to El. 225 in order not to interfere with 14-foot navigation at Lock 25. A similar study was undertaken for the Ogden Island reach, but with opposite results. In this case, it was found that the three cuts on the north side of Ogden Island must be made before the pool is raised to El. 225 in order to maintain 14-foot navigation during construction of Long Sault Dam. With the pool at El. 225, the Morrisburg Canal will be flooded. Traffic will then be forced to use the north channel past Ogden Island. Velocities in this channel will be

much too high for navigation with this pool level unless adequate channel enlargement has been secured.

143. Two conditions were figured - one with the three cuts on the north side of Ogden Island completed, and one with these three cuts and the cuts in the south channel also completed. The results of these computations, are shown on graphic form on Plate 17 of this appendix. The present Rapide Plat velocity of 10.3 miles per hour is plotted on this graph and also the present velocity in the Goose Neck Island constriction at about Mile 88 - 6.7 miles per hour. Fourteen-foot navigation is already being carried on under the latter velocity. Therefore, it was considered satisfactory if the velocity in the Rapide Plat could be lowered to this value for this temporary condition. Velocities computed for the above two conditions are shown as curves on the graph. It will be noted that the three north channel cuts alone will accomplish the desired velocity reduction. It has been recommended, therefore, that the three cuts on the north side of Ogden Island be completed before the pool at Long Sault Dam is raised to El. 225.

CROIL ISLAND NORTH CHANNEL AND FARRANS POINT CANAL

144. The Farrans Point Canal is located at about Mile 96 on Plate 19 of Appendix III-0(1) and on Plate M-II of the main report. The canal is just a little over a mile long and Lock 22 is located at the lower end. This canal will be flooded when the pool at the dam is raised to about El. 207 and navigation will have to use the river channel parallelling the canal. The velocities which will prevail in the river under this raised pool condition were investigated and found to be satisfactory for navigation based on the same criterion as used in the case of the Ogden Island north channel. Velocities would not exceed 6.7 miles per hour under this condition. It was not necessary, therefore, to make any improvement in the Croil Island north channel, to take care of this temporary condition. No permanent improvement was necessary in this reach because velocities will be well below that required by the ice criterion when the pool is fully raised.

CORNWALL CANAL

145. The Cornwall Canal on the Canadian side of the river extends from about Mile 100 to Mile 110, the Long Sault Dam and Barnhart Island powerhouse being in the middle of this reach. Navigation durin construcmust also be maintained in this 14-foot canal. The plan for maintaining navigation in this canal is very closely connected with the construction program of the Long Sault Dam and the details of this plan are discussed in the design analysis for the dam - Appendix III-22(3), Section XIV. The plan will be repeated here briefly for the sake of completeness.

146. The dike of the Cornwall Canal and the walls and gates of Lock 21 will be raised to El. 210 in order to make navigation possible until the pool at the dam is raised above El. 209. According to the construction program [Plate 12 of Section XIV, Appendix III-22(3)], the pool will be raised from El. 209 to El. 225 in about three days. During this brief period navigation will necessarily be interruped. Then, with the

pool at or above El. 225, the 14-foot navigation can use the new Long Sault Canal. When the pool reaches El. 238 the relocated central portion of the Cornwall Canal, with its new lock, and the undisturbed eastern part of that canal will afford an alternate route for 14-foot navigation which will be particularly advantageous for vessels bound to or from the wharves at Cornwall. Should there be any reason to anticipate delay in the opening of Long Sault Canal a modification of the upper sill of the new lock of the Cornwall Canal will permit the use of this route as soon as the pool reaches El. 225

CORNWALL ISLAND REACH

147. The Cornwall Island reach is downstream from the Long Sault Dam and Barnhart Island powerhouse. It extends from about Mile 107 to about Mile 114, as shown on Plate M-I of main report and on Plate 34 of Appendix III-O(1). Mile 107 is at the head of Cornwall Island where Grass River enters the St. Lawrence River and where the proposed Long Sault Canal ends. Mile 114 is at the lower end of Cornwall Island. The river in this reach is split into two channels of about equal size by Conrwall Island. The north channel continues upstream to the Barnhart Island powerhouse and to Long Sault Dam. The south channel stops at the head of Cornwall Island. The easterly entrance to the Long Sault Canal is located at the upper end of the south channel.

148. Slack water from Lake St. Francis extends up to about the middle of Cornwall Island. Above this point, the water surface has an appreciable slope due to the constricted nature of both the north and south channels. Low water in this reach is about El. 152 at the lower end of the island and about El. 155 to about El. 157 at the upper end, the higher level being in the north channel. A drop of 2 feet, therefore, exists in Polly's Gut at the upper end of Cornwall Island.

149. The south channel is to be improved for navigation. The north channel is to be enlarged to relieve velocities in the south channel. Excavation in both channels will help to lower tailwater levels at Barnhart Island powerhouse. In addition to the cuts shown on Plate 34 of Appendix III-O(1), there will be some cutting in the main channel just downstream from the Barnhart Island powerhouse which will have for its purpose the lowering of tailwater levels. This additional cuts is shown on Plate M-I of the main report. All of these cut should be considered together because of their effect on tailwater levels.

150. As stated in paragraph 59 above, time did not permit a detailed analysis of these cuts. A plan was laid out similar to the Original 238-242 Plan to serve until study on this project is resumed. It is proposed that when study is resumed, the same criterion for maximum navigation channel velocity be applied to this reach as was applied to the Galop Island reach and that a detailed backwater study similar to that made for the Galop Island reach be made. It is also recommended that a model study of this reach be made to determine the detailed shapes of the cuts in order to avoid undesirable cross currents. It is expected that cross currents will present a problem, particularly in the upper end of the south channel where maximum velocities will prevail and where

side inflow comes in from Polly's Gut and from Grass River.

151. A bottom grade of El. 124 for the navigation channel will give the desired 27-foot depth below low water. A minimum of 442-foot bottom width of cut was used in the slack-water area in the lower end of the reach, in accordance with criterion b (Par. 41b above). A minimum of 1000-foot width was used in the high-velocity reach at the upper end where navigation conditions may be difficult. The cut was widened out at the entrance to the canal to permit ample maneuvering space. The mouth of Grass River was also enlarged to improve entrance conditions.

152. It will be noted that the excavation pattern of the Original 238-242 Plan, shown on Plate M-II of the main report, does not appear similar to excavation pattern shown on Plate 34 of Appendix III-O(1). The reason for this is that different sounding data were used in preparing the two plans. This office used the more recent sounding data of the U.S. Lake Survey.

SECTION VII - MODEL TESTS

153. General. The need for model studies of the critical reaches of the International Rapids Section has been stressed at various points throughout this appendix. It has been brought out that the river channels are so tortuous and the banks so irregular that it would be impossible to predict with any degree of reliability the location of cross currents and eddies and to work out remedies for these undesirable conditions by analytical methods. It has been brought out that the backwater computations by which the division of flow among the various channels was computed and the velocity determinations are at best only approximate because of the many questionable assumptions which had to be made.

154. Model tests are not the cure-all for all the above deficiencies in knowledge, but model tests do constitute another method of design which, if found to agree with the computations, produce more assurance that the plan of improvement proposed is the correct one. In some problems, model tests give a more accurate answer and a more detailed one than computations. This is particularly true in the case of cross currents and eddies and the determination of remedies therefor. It was felt also that models might produce a better answer to the division of flow problem and hence a better determination of the maximum velocities in the navigation channel.

155. The importance of the project and the great expenditures involved make it mandatory that no avenue of approach be left unexplored in an attempt to obtain a satisfactory design of navigation channel. It would be unfortunate to find, after building the project, that undesirable currents existed at many places in the navigation channel. Experimentation in the prototype might then prove many times more expensive than in a model. In view of this possibility, this office considers it advisable to conduct model tests of all of the critical channel sections before the project is built. It is the understanding of this office that engineers of the Canadian Department of Transport are of the same opinion.

156. The question of model tests was taken up with the U.S. Waterways Experiment Station at Vicksburg, Mississippi, with a view to determining just what types of models would be suitable to the above problems. It was the opinion of all concerned after these conferences that the channel studies could be made in three separate models as follows:

- a. Galop Island and Toussaints Island reaches (from Chimney Point to Iroquois Dam).
- b. Point Three Points and Ogden Island reachs (from Iroquois Dam to Canada Island).
- c. Cornwall Island reach (from Barnhart Island powerhouse to the foot of Cornwall Island).

As mentioned in paragraph 128 above, it might also prove desirable to make an enlarged model of the upper entrance to the Point Rockway Canal and Iroquois Dam, in order to study the effect of the draw of the dam

on currents in the canal entrance. Model tests of the Long Sault Island were also proposed to study cofferdam and diversion problems, but these are considered tests in connection with the construction of Long Sault Dam, and are treated in the design analysis of the dam.

157. Distorted scale models were proposed by the Waterways Experiment Station. A distortion of 1 to 5 was proposed, i.e., the vertical scale would be 5 times as large as the horizontal scale. The costs of the channel models given in the main report refer to models with a vertical scale of 1:160 and a horizontal scale of 1:800. It developed later, however, that these scales might have to be doubled to obtain the accuracy desired i.e., vertical scale 1:80 and horizontal scale 1:400.

158. A distortion ratio of about 1:5 had been found satisfactory in previous testing at the Experiment Station. Very good agreement had been obtained between model and prototype currents in connection with the model study of the East River navigation channel, the results of which are reported in Technical Memorandum No. 125-3 issued by the Experiment Station. Scales of 1:80 and 1:480 were used in this model -- a distortion of 1:6. Some degree of success was also obtained in models of the Pryors Island and Manchester Island reaches of the Ohio River. The Pryors Island model was constructed to scales of 1:150 and 1:600 -- a distortion of 1:4 (Technical Memorandum No. 107-1). The Manchester Island model was constructed to scales of 1:80 and 1:300 -- a distortion of 1:375 (Technical Memorandum No. 181-1). Considering the depths and widths to be reproduced in the St. Lawrence channels, it appeared that a distortion of 1:5 would be about right -- the main objective being to retain the same general shape of channel so that currents will be reproduced as accurately as possible. If a channel has great width compared to de th, the model channel must also have great width compared to depth so that end effects will not distort the results. For instance, a channel cut 850 feet wide and 30 feet deep has a ratio of width to depth of about 30. With 1:5 distortion, the model channel would have width-depth ratio of 6 which is still broad enough that end effects will not produce an appreciable distortion. If this ratio is kept large enough, the Experiment Station considers a distorted model practically as good as an undistorted model, the cost of which would be many times that of a distorted model.

159. <u>Galop Island and Toussaints Island Reach Model:</u> As stated above, this model would extend from Chimney Point to Iroquois Dam, a prototype distance of 10 miles. Below are listed some of the more important problems that could be studied with this model:

<u>a.</u> Relative merits of Recommended and Alternate Plans.

<u>b.</u> Necessity for Dike No. 5 in Alternate Plan and width of Chimney Island cut required without Dike No. 5.

<u>c.</u> Necessity for straighter navigation channel in the vicinity of Chimney Point in Recommended Plan.

<u>d.</u> Width of Galop Island cuts necessary to reduce maximum navigation channel velocities to 4.5 feet per second

in each plan.

e. Location of ice cribs at head of Galop Island.

f. Effect of construction program in the Galop Island reach on Lake Ontario levels and outflows.

g. Adequacy of Lalone and Lotus Island cuts.

h. Adequacy of Sparrowhawk Point and Toussaints Island cuts.

i. Approach conditions at entrance to Point Rockaway Canal (separate model may prove necessary for this).

j. Velocity conditions above Iroquois Dam with view to formation of ice sheet.

k. Necessity for changes in any of the cuts or dikes to produce satisfactory current directions in navigation channel.

l. Location of spoil areas.

160. Point Three Points and Ogden Island Reach Model: This model would extend from Iroquois Dam to Canada Island, a prototype distance of 8 miles. Some of the more important problems which could be studied in this model are the following:

a. Approach conditions at lower entrance to Point Rockaway Canal.

b. Current conditions in navigation channel.

c. Velocities during ice formation conditions; adequacy of cuts therefor.

d. Location of spoil areas.

e. Velocities in Ogden Island north channel when Morrisburg Canal is flooded during the closure period of Long Sault Dam.

f. Effect of various cuts on river stages at upper entrance to Morrisburg Canal before the start of construction of Long Sault Dam and during various construction stages up to stage at which the canal is flooded.

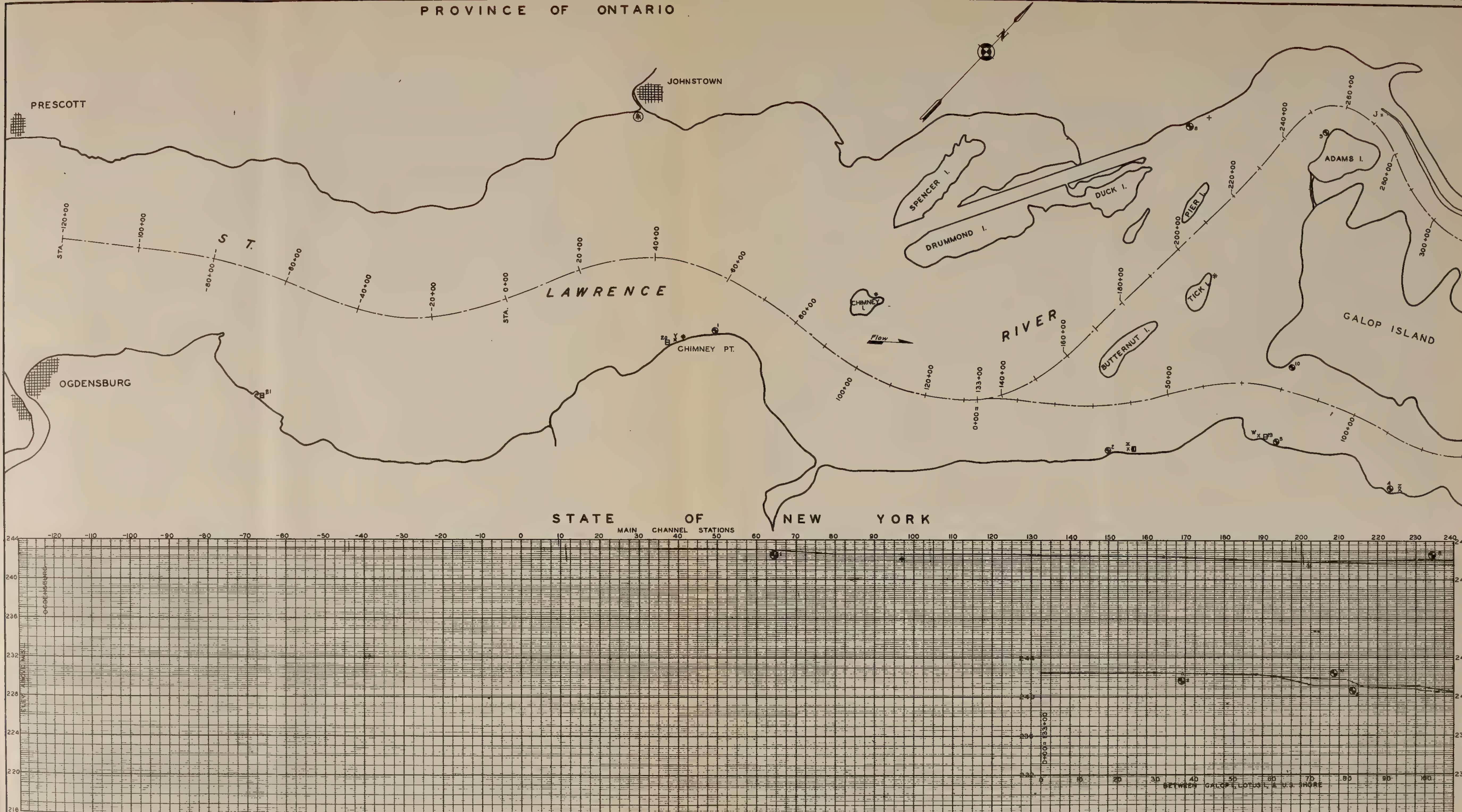
g. Effect of various cuts on the stage at Lock 25, both before the start of construction and during construction.

161. <u>Cornwall Island Reach Model</u>: This model would extend from the Barnhart Island powerhouse to the foot of Cornwall Island, a prototype distance of about 8 miles. Some of the more important problems in this reach, which could be studied by a model, would be the following:

- a. Adequacy of the plan finally worked out for this reach.
- b. Velocities in navigation channel.
- c. Currents in navigation channel, especially at the junction of Grass River, Polly's Gut, and the Ogden Island south channel.
- d. Effect of the various cuts on tailwater at Barnhart Island powerhouse.
- e. Construction procedures.

162. The rating curves, low water profiles, current direction drawings, and hydrographic drawings prepared by this office are available for use in the model studies. Available also are the discharge measurements of the Hydro-Electric Power Commission of Ontario, which show the natural division of flow among the various channels in some reaches of the river. Model roughness can be adjusted to give the division of flow and water surface elevations obtained from the above data. For higher than observed water surface elevations, the natural roughness of the model will have to be continued farther up the banks. Also for cuts, a roughness simulating the roughness to be expected in the prototype will have to be reproduced. Small errors may develop in the last two steps but these are not expected to be as great as those inherent in the computations. In an irregular channel like the International Rapids Section of the St. Lawrence River, a great part of the resistance to flow is form resistance (or eddy resistance) which should be fairly accurately reproduced. It is only the skin friction part of the resistance that is questionable. By the use of good judgment in the simulation of skin friction, the error in this step can probably be made inappreciable. An answer at least as accurate as the computation results should be obtained and the likelihood is that the model answer will be more accurate than the computations. If it is only as accurate, at least there will be two answers, the model and computations, on which to base judgment as to the characteristics of the final design.

163. High priority should be assigned to the model tests when work on the project is resumed, if construction appears imminent, because model studies such as the above, if performed carefully and thoroughly, will require from 6 months to a year to complete, depending upon the number of plans it is desired to test. All 3 models would probably have to be constructed and tested simultaneously, if the results were desired in that time.



GAGE LEGEND

- HEPC AUTO-PERMANENT
- " " TEMPORARY
- " " STAFF
- DEPT RWYS & CANALS
- H.L. COOPER
- DEPT. NAVAL SERVICE
- N.Y. & ONT. POWER CO.
- ALUMINUM CO.
- U.S. LAKE SURVEY
- BOARD OF ENG., DEEP WWYS
- DEPT PUBLIC WORKS
- DEPT TRANSPORTATION

SCALE: 1 IN. = 4 FT. VERT.
1 IN. = 1000 FT. HOR.

NOTE:
PROFILE OF RIGHT BANK IS SHOWN THUS ————
" " LEFT " " " — — — —
U.S. LAKE SURVEY STANDARD LOW WATER DATUM (197000 C.F.S.)

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

IN 9 SHEETS — SHEET NO. 1 — SCALE: 1" = 1000'

1000 0 1000 2000

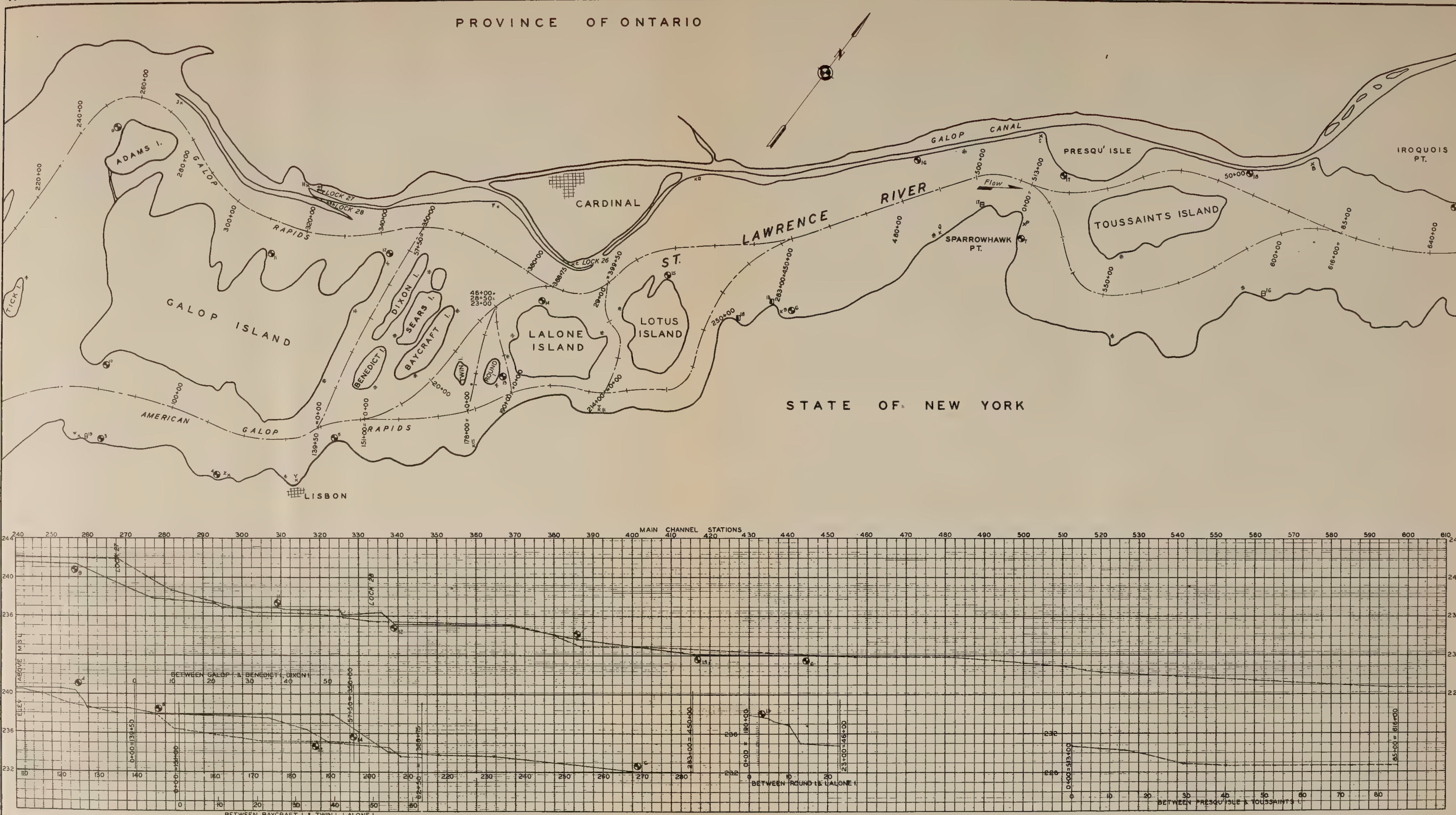
U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED:	RECOMMENDED:	APPROVED:
D.C. Bondurant, ASSOC. ENGINEER	HEAD ENGR.; LT. COL., CORPS OF ENGINEERS	COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY: C.H.L-H. CHECKED BY: D.C.B.	SX-1-532/2 FILE NO.	TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

Plate 2

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



SCALE: 1" = 4' VERT.
1" = 1000' HOR.

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE.
LEFT " " " " BROKEN "
U.S. LAKE SURVEY STANDARD LOW WATER DATUM, (197000 C.F.S.)

GAGE LEGEND

H.E.P.C. AUTO.- PERMANENT	+
" " TEMPORARY	+
" STAFF	x
DEPT. R'WYS & CANALS	+
H.L. COOPER	B
DEPT. NAVAL SERVICE	A
N.Y. & ONT. POWER CO	B
ALUMINUM CO.	B
U.S. LAKE SURVEY	B
BOARD ENG DEEP W'WYS	D
DEPT. PUBLIC WORKS	A
DEPT. TRANSPORTATION	

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

IN 9 SHEETS — SHEET NO. 2 — SCALE 1" = 1000'

1000 0 1000 2000

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: D.C. Bondurant, ASSOC. ENGINEER

RECOMMENDED: HEAD ENGR. — LT. COL., CORPS OF ENGINEERS

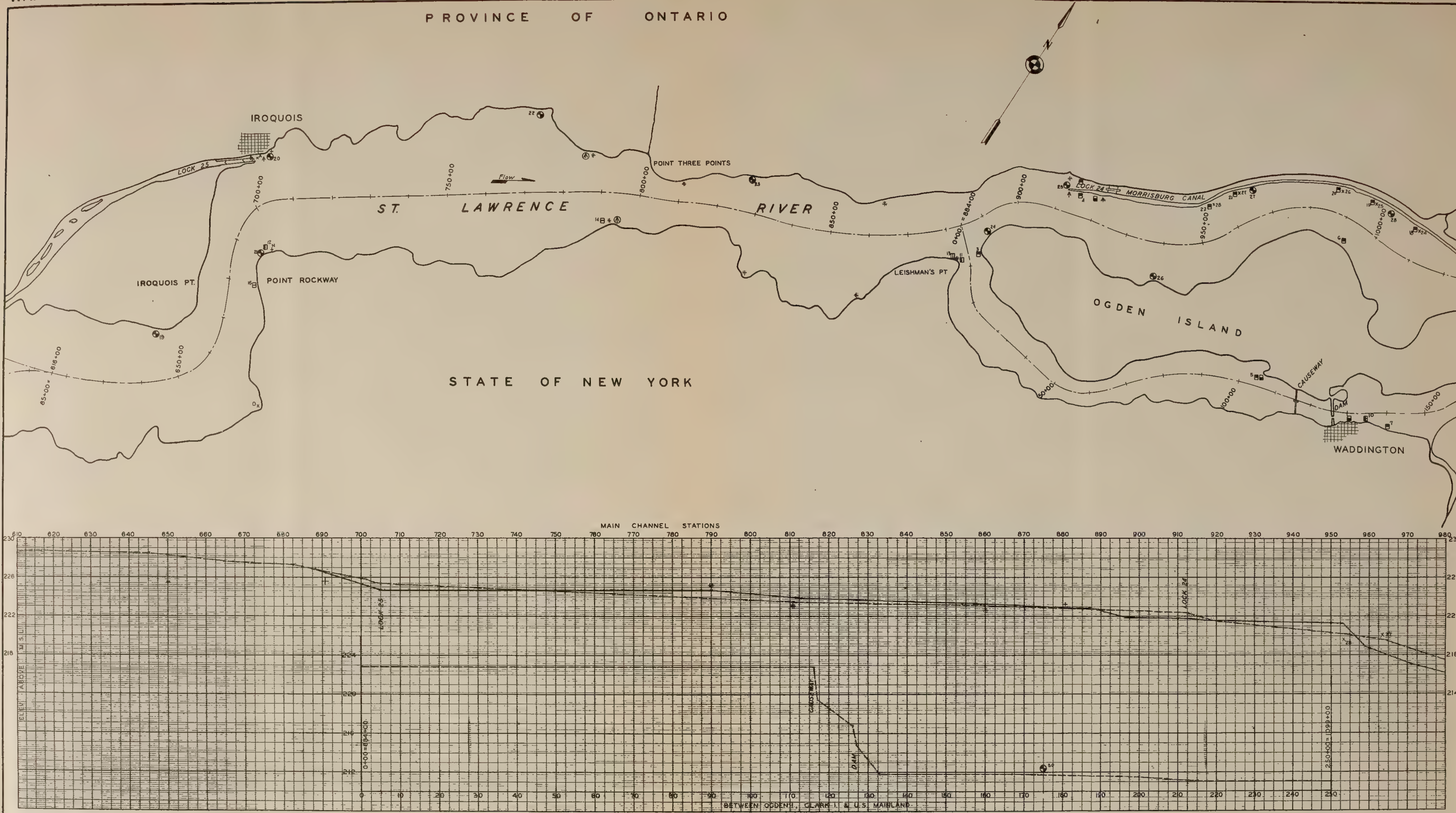
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: C.H.L.-K. CHECKED BY: D.C.B.

SX-1-532/3 FILE NO.

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

Plate 3



SCALE: 1" = 4' VERT.
1" = 1000' HOR.

GAGE LEGEND

H.E.P.C. AUTO-PERMANENT
" " TEMPORARY
" STAFF
DEPT R'W'YS & CANALS
H.L. COOPER
DEPT. NAVAL SERVICE
N.Y. & ONT. POWER CO
ALUMINUM CO
U.S. LAKE SURVEY
BOARD ENG. DEEP W'W'YS
DEPT. PUBLIC WORKS
DEPT. TRANSPORT

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE.
LEFT " " " " BROKEN "
U.S. LAKE SURVEY STANDARD LOW WATER DATUM (197,000 C.F.S.)

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

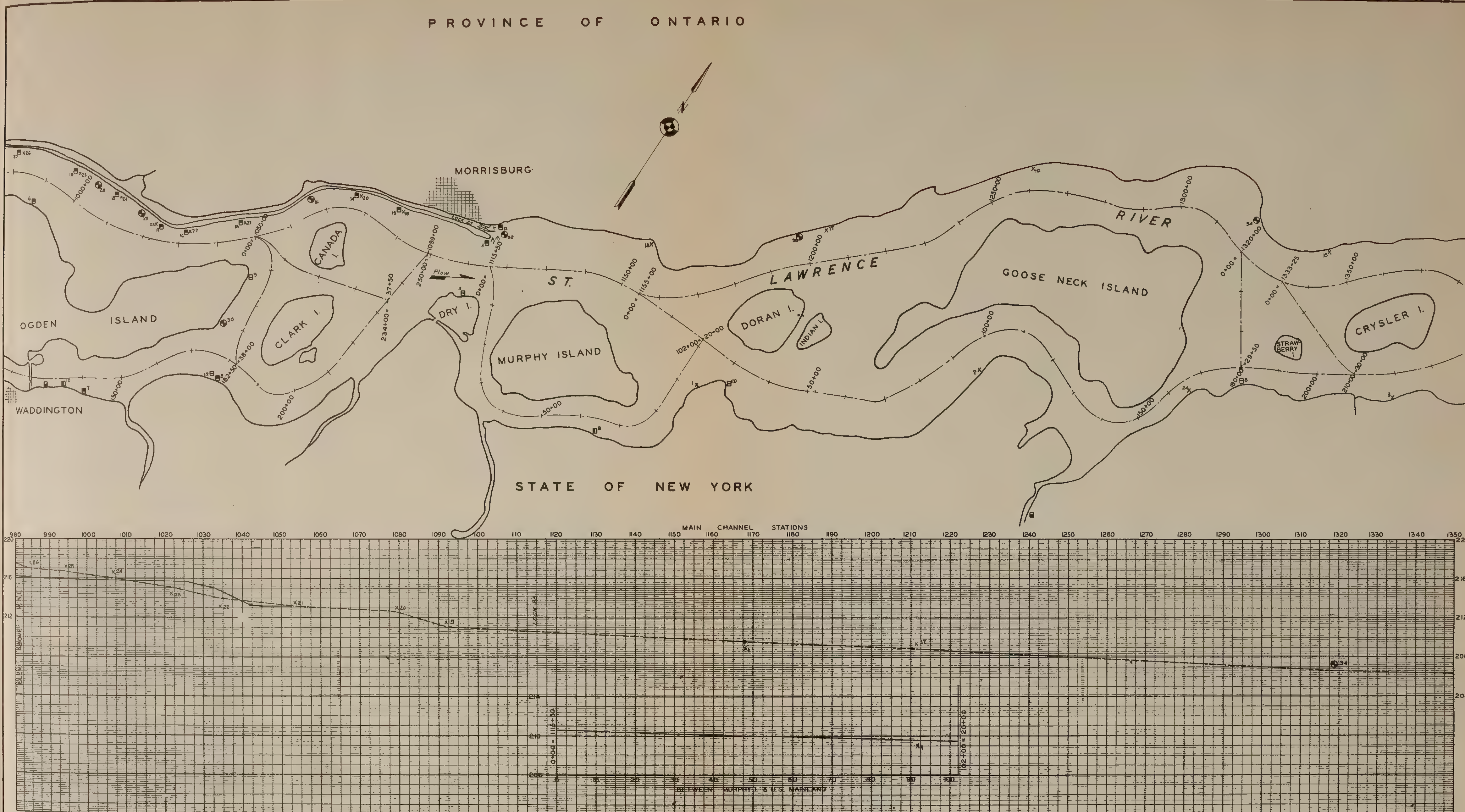
IN 8 SHEETS — SHEET NO. 3 — SCALE: 1" = 1000'

1000 0 1000 2000

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: D.C. Bondurant, ASSOC. ENGINEER
RECOMMENDED: [signatures] HEAD ENGR.; LT. COL. CORPS OF ENGINEERS
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: C.H.L.H.
CHECKED BY: D.C.B.
SX-1-532/4
FILE NO.
TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED 1941



GAGE LEGEND

H.E.P.C AUTO-PERMANENT	+
" " TEMPORARY	
" STAFF	x
DEPT. R'W'YS & CANALS	
H.L. COOPER	
DEPT NAVAL SERVICE	
N.Y. & ONT. POWER CO.	
ALUMINUM CO.	
U S LAKE SURVEY	
BOARD ENG., DEEP W'W'YS	
DEPT. PUBLIC WORKS	
DEPT. TRANSPORT	

SCALE: 1" = 4' VERT.
1" = 1000' HOR.

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE.
LEFT " " " " BROKEN "
U. S. LAKE SURVEY STANDARD LOW WATER DATUM (197000 C.F.S.)

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

IN 9 SHEETS — SHEET NO. 4 — SCALE: 1" = 1000'

1000 0 1000 2000

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: D. C. Bondurant, ASSOC. ENGINEER
RECOMMENDED: HEAD ENGR. — LT. COL. CORPS OF ENGINEERS
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

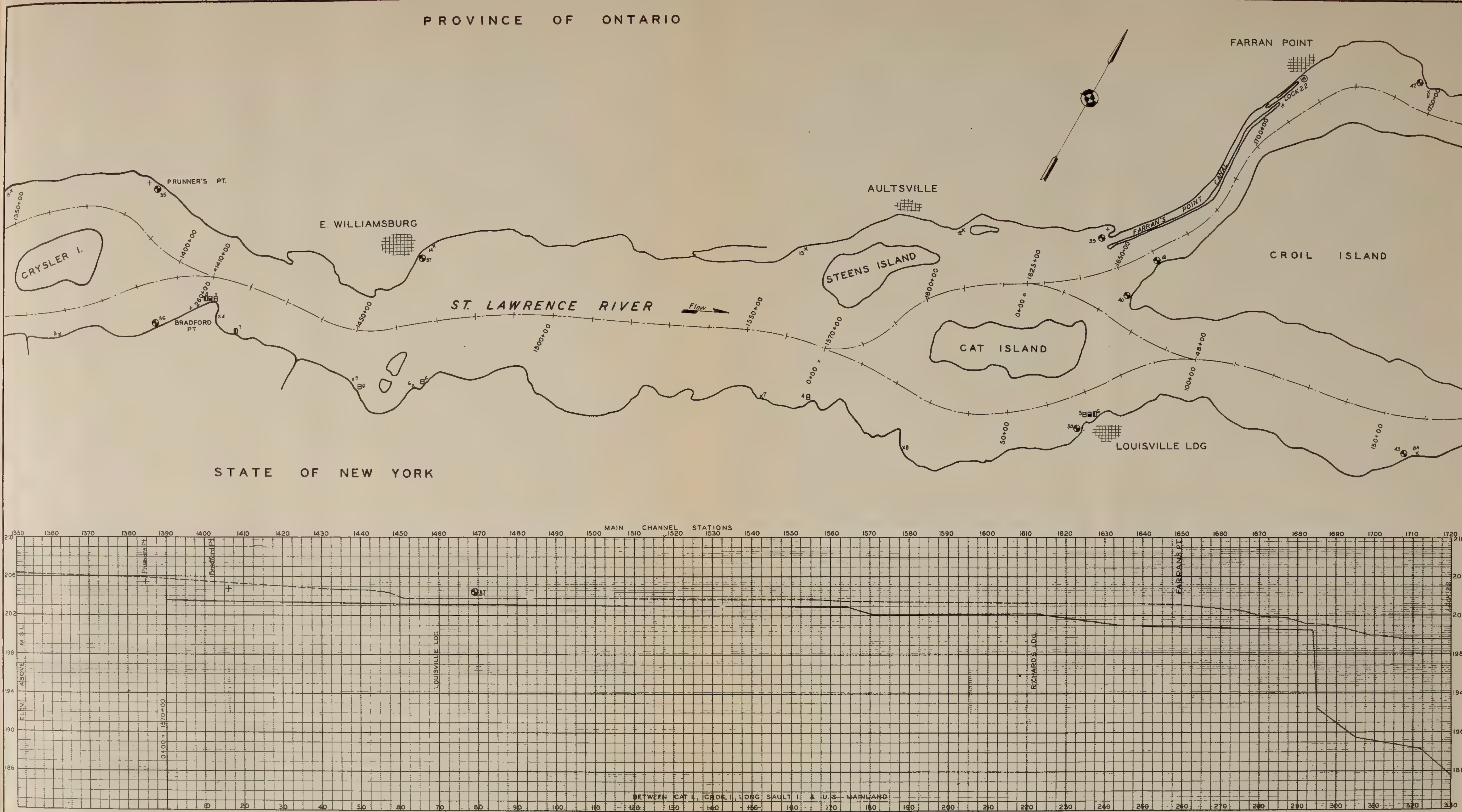
DRAWN BY: G.H.L-H
CHECKED BY: D.C.B.

SX-1-532/5
FILE NO.

TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED 1941

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



GAGE LEGEND

H E P C AUTO-PERMANENT	+
" " TEMPORARY	⊕
" STAFF	x
H L COOPER	B
NY & ONT POWER CO	▣
ALUMINUM CO	▣
U.S. LAKE SURVEY	▣
BOARD ENG. DEEP W'W'YS	▣
DEPT R'WYS & CANALS	✣
" NAVAL SERVICE	⩓
" PUBLIC WORKS	Ⓐ
" TRANSPORT	⊕

SCALE: 1" = 4' VERT.
1" = 1000' HOR.

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE.
LEFT " " " " BROKEN "
U.S. LAKE SURVEY STANDARD LOW WATER DATUM (197,000 C.F.S.)

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

IN 9 SHEETS SHEET NO. 5 SCALE: 1" = 1000'

1000 0 1000 2000

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: D.A. Bondurant, ASSOC. ENGINEER
RECOMMENDED: HEAD ENGR; LT. COL., CORPS OF ENGINEERS
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: C.H.V.H.
CHECKED BY: G.C.B.

SX-I-532/6
FILE NO.

TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED 1941

Plate 6

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

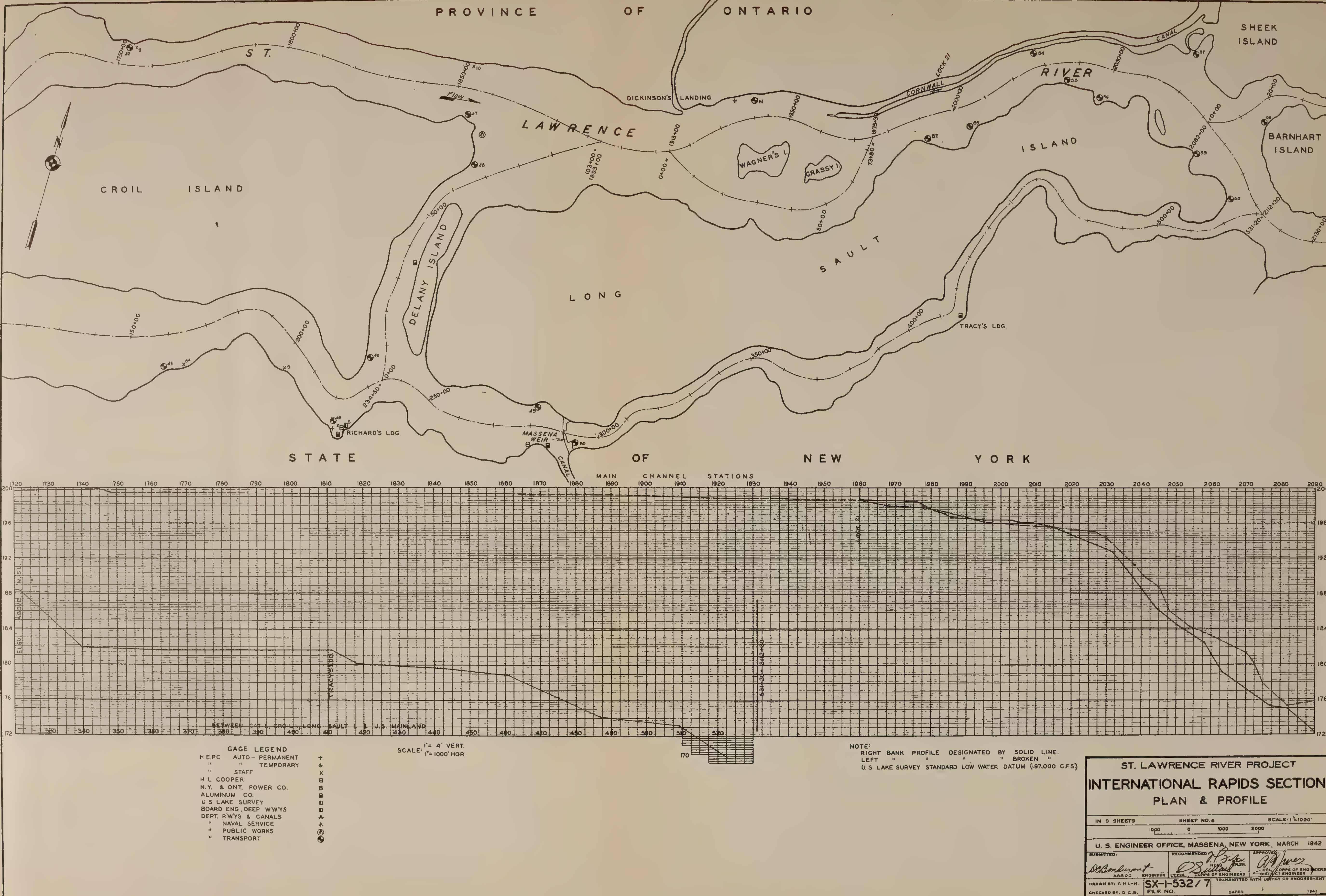
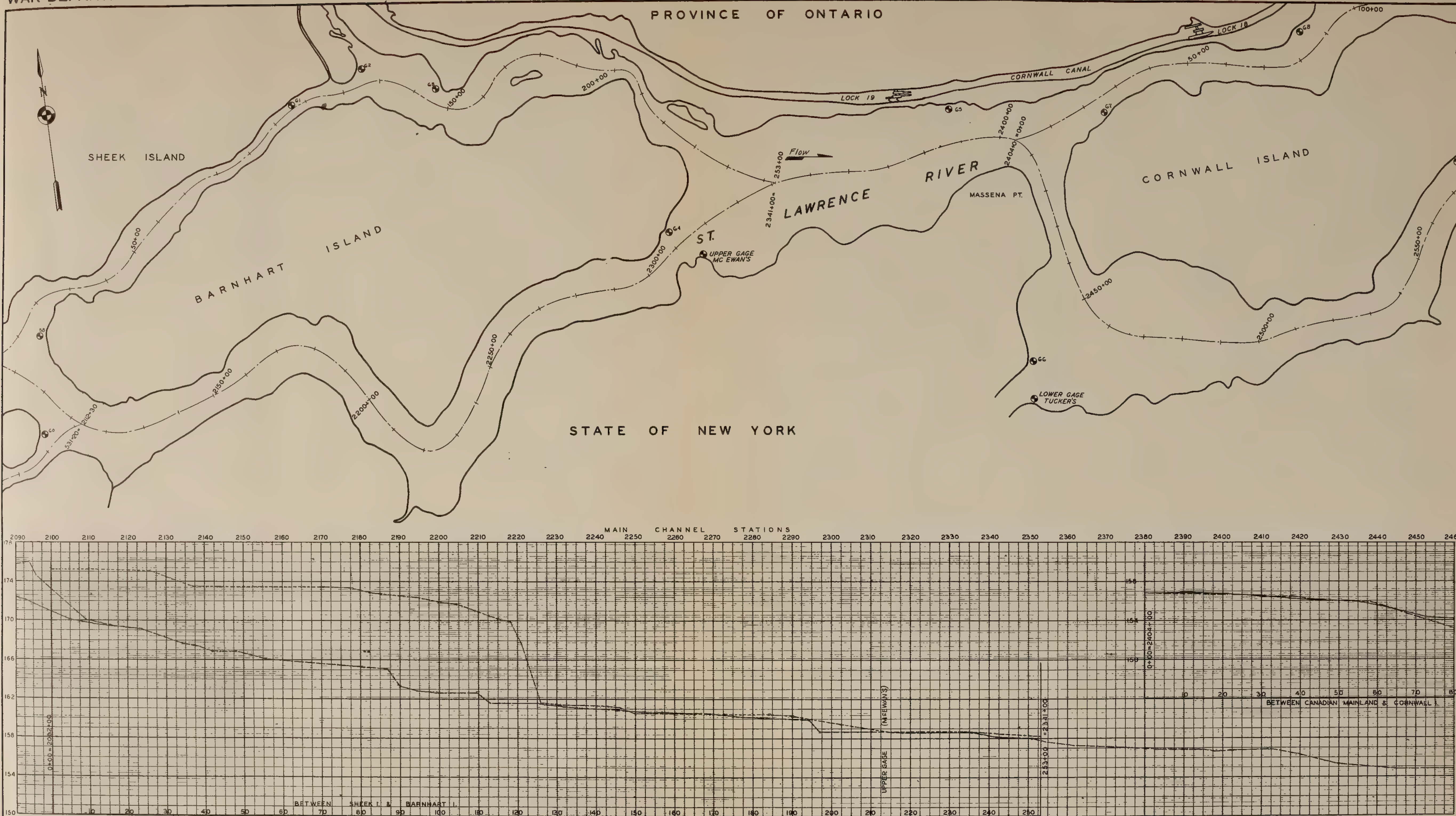


Plate 7

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



SCALE: 1" = 4' VERT.
1" = 1000' HOR.

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE
LEFT " " " BROKEN "
U.S. LAKE SURVEY STANDARD LOW WATER DATUM (97,000 C.F.S.)
DEPT. OF TRANSPORT GAGE

ST. LAWRENCE RIVER PROJECT

INTERNATIONAL RAPIDS SECTION

PLAN & PROFILE

IN 3 SHEETS — SHEET NO. 7 — SCALE: 1" = 1000'

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: ASSOC. ENGINEER — RECOMMENDED: HEAD ENGR.; LT. COL., CORPS OF ENGINEERS — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: C.H.L.H. — CHECKED BY: O.C.B.

SX-1-532/8
FILE NO.

TRANSMITTED WITH LETTER OR ENDORSEMENT — DATED 1941

Plate 8

SCALE: 1" = 4' VERT.
1" = 1000' HOR.

NOTE:
RIGHT BANK PROFILE DESIGNATED BY SOLID LINE.
LEFT " " " " BROKEN "
U.S. LAKE SURVEY STANDARD LOW WATER DATUM (197,000 C.F.S)
DEPT. OF TRANSPORT GAGE ⊕

ST. LAWRENCE RIVER PROJECT
INTERNATIONAL RAPIDS SECTION
PLAN & PROFILE

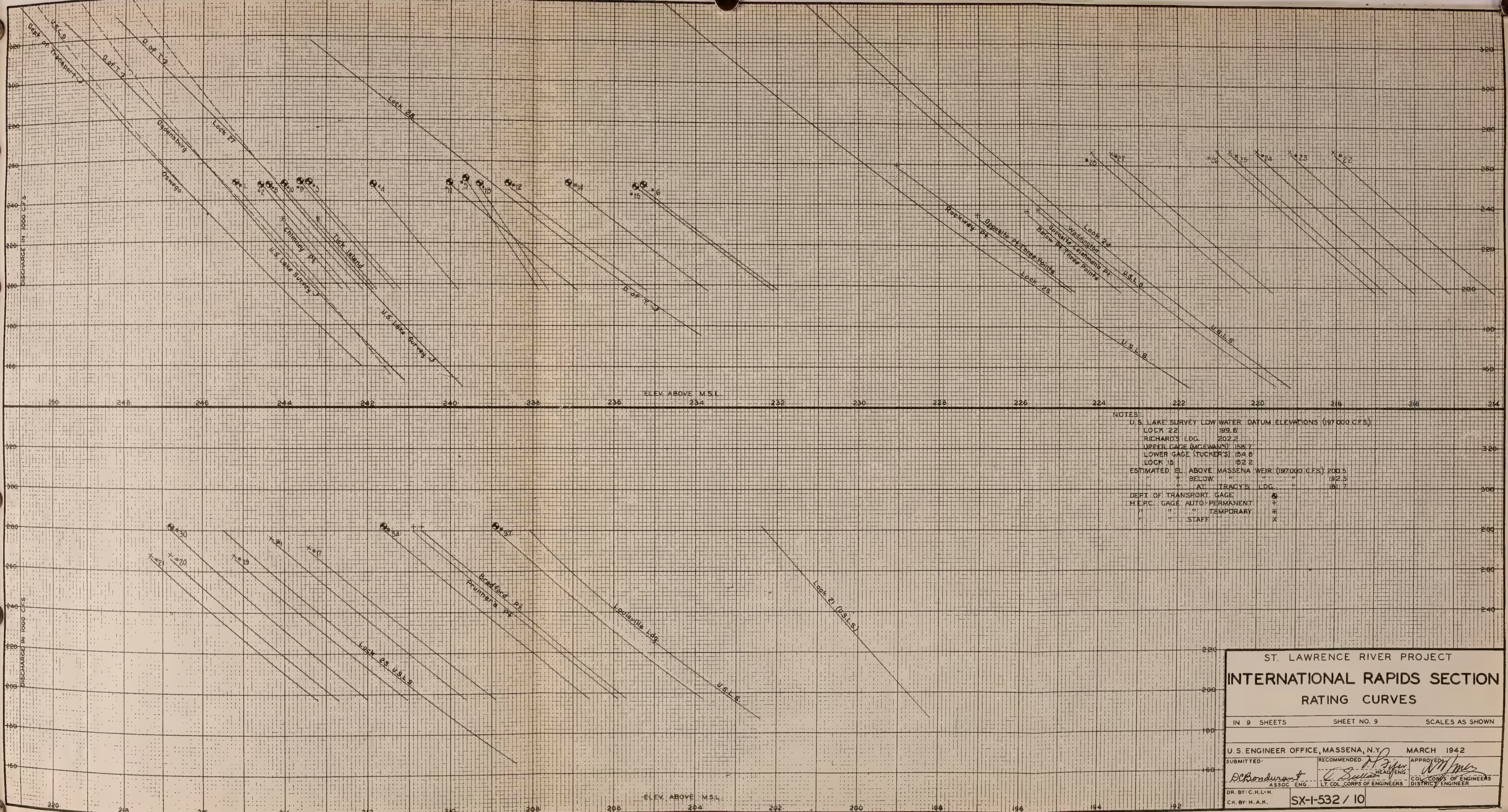
IN 9 SHEETS — SHEET NO. 8 — SCALE: 1" = 1000'

1000 0 1000 2000

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, MARCH 1942

SUBMITTED: D.C. Bondurant, ASSOC. ENGINEER
RECOMMENDED: [signatures] HEAD ENGR.; LT. COL., CORPS OF ENGINEERS
APPROVED: [signature] COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: C.H.L.H.
CHECKED BY: D.C.B.
SX-1-532/9
FILE NO.
TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED 1941



Lock 28
Lock 27
Ogdensburg
Oswego
Chimney Pt.
Tick Island
U.S. Lake Survey
D. of T.
Rockway Pt.
Opposite Pt. Three Points
Below Pt. Three Points
Waddington
Lock 25
Lock 24
U.S.L.S.
Lock 21 (U.S.L.S.)
Bradford Pt.
Prumara Pt.
Louisville Ldg.
Lock 23 U.S.L.S.
DISCHARGE IN 1000 C.F.S.
ELEV. ABOVE M.S.L.
NOTES:
U.S. LAKE SURVEY LOW WATER DATUM ELEVATIONS (197 000 C.F.S.)
LOCK 22 199.8
RICHARD'S LDG. 202.2
UPPER GAGE (MCEWAN'S) 158.7
LOWER GAGE (TUCKER'S) 154.8
LOCK 15 152.2
ESTIMATED EL. ABOVE MASSENA WEIR (197 000 C.F.S.) 200.5
" " BELOW " " " 192.5
" " AT TRACY'S LDG. " 181.7
DEPT. OF TRANSPORT GAGE
H.E.P.C. GAGE AUTO-PERMANENT +
" " " TEMPORARY
" " STAFF X
ST. LAWRENCE RIVER PROJECT
INTERNATIONAL RAPIDS SECTION
RATING CURVES
IN 9 SHEETS
SHEET NO. 9
SCALES AS SHOWN
U.S. ENGINEER OFFICE, MASSENA, N.Y.
MARCH 1942
SUBMITTED:
DCBondurant
ASSOC. ENG.
RECOMMENDED:
HEAD ENG.
LT. COL., CORPS OF ENGINEERS
APPROVED:
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER
DR. BY: C.H.L-H.
CK. BY: H.A.K.
SX-1-532 / 10

Plate 10


DISTANCE IN 1000s OF FEET
ELEVATION IN FEET
Condition at Maximum Headwater at Power House - May 1931 - Q=200,000 c.f.s.
Condition of Maximum Lake Level, also Maximum Flow at Maximum Level - May 1870 - Q=310,000 c.f.s.
Condition of Minimum Flow - Nov. 1934 - Q=180,000 c.f.s.
Minimum Lake Level at Maximum Flow - Oct. 1868 - Q=310,000 c.f.s.
Condition at Minimum Lake Level - Feb. 1936 - Q=165,000 c.f.s.
Condition of Minimum Headwater at Power House - Jan. 1936 - Q=162,000 c.f.s.
CHIMNEY PT.
HD. OF GALOP ISLAND
PT. OF GALOP ISLAND
LALONE ISLAND
LOTUS ISLAND
SPARROW HAWK PT.
IROQUOIS PT.
ROCKAWAY PT.
IROQUOIS
POINT THREE POINTS
HEAD OF OGDEN ISLAND
WADDINGTON
FOOT OF OGDEN ISLAND
MORRISBURG
HEAD GOOSENECK ISLAND
CHRYSLER ISLAND
WEAVERS POINT
AULTSVILLE
OAT ISLAND DAMSITE
FARRANS POINT
LONG SAULT DAM
BARNHART ISLAND PH.
TAIL BAY - BARNHART ISLAND PH.
COTTON HILL - CORNWALL
Present River Surface Q=200,000 c.f.s.
Present River Surface Q=216,000 c.f.s.
M.S.L.S. Drawings
Main Channel
Power House Channel
TAILWATER ELEVATIONS
Notes:
Natural Water Surface Profiles taken from U.S. Lake Survey drawings dated 10-12-24.
Backwater Curves taken from data obtained from Dept. of Transport, Ottawa, dated Nov. 1940.
Profile of Channel plotted from topographic maps of St. Lawrence Waterway, scale 1"=1000', dated Jan. 1940.
ST. LAWRENCE RIVER PROJECT
BACKWATER PROFILES
FOR
ORIGINAL 238-242 PLAN
IN ONE SHEET
SCALES AS SHOWN
U.S. ENGINEER OFFICE, MASSENA, N.Y., DEC. 1940
BD-A-1/5
CROSS SECTION PAPER 10 x 10 = 1 INCH
EUGENE DIETZGEN Co.
BD-A-1/D

PLATE II

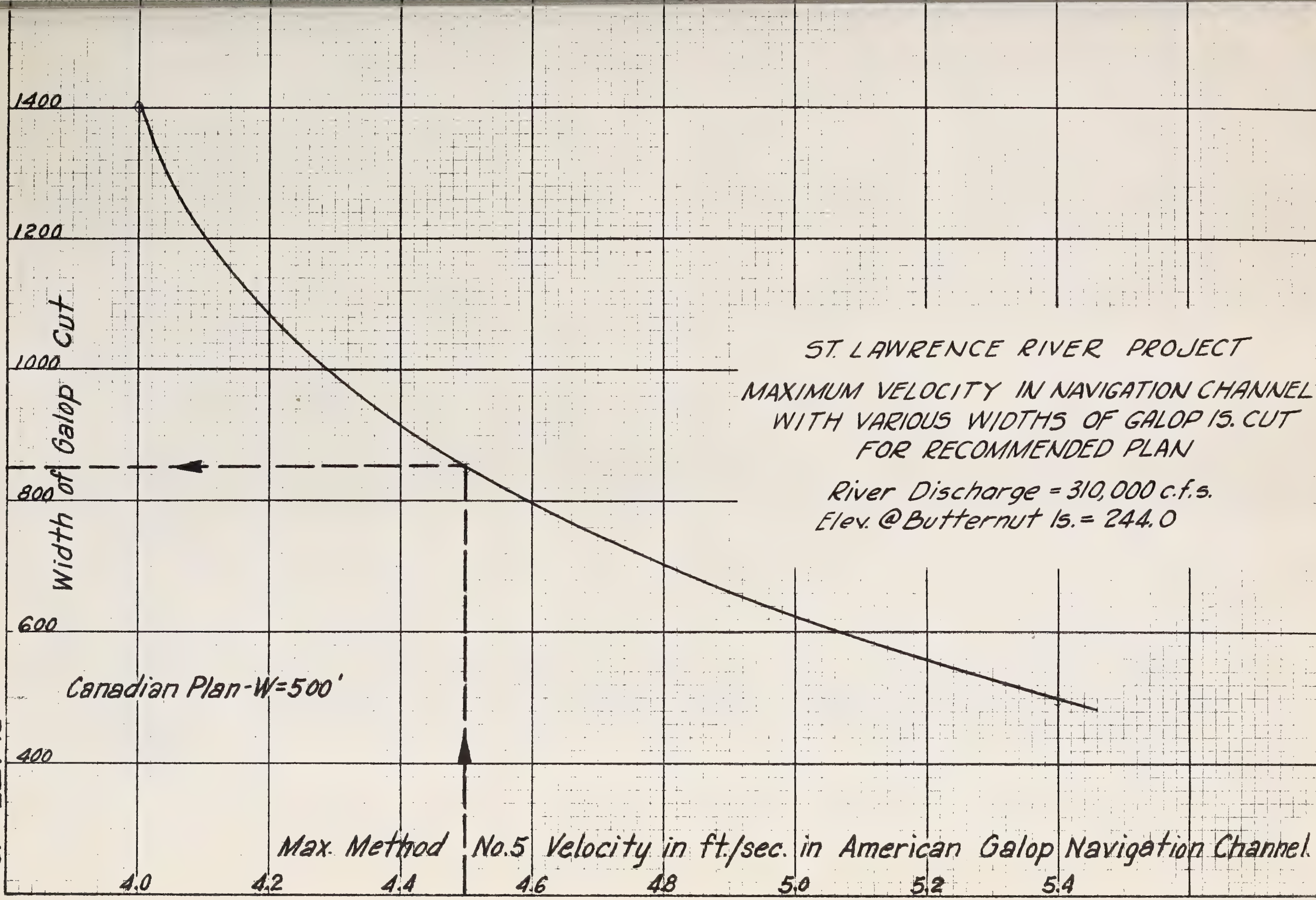


PLATE 12

PLATE 12

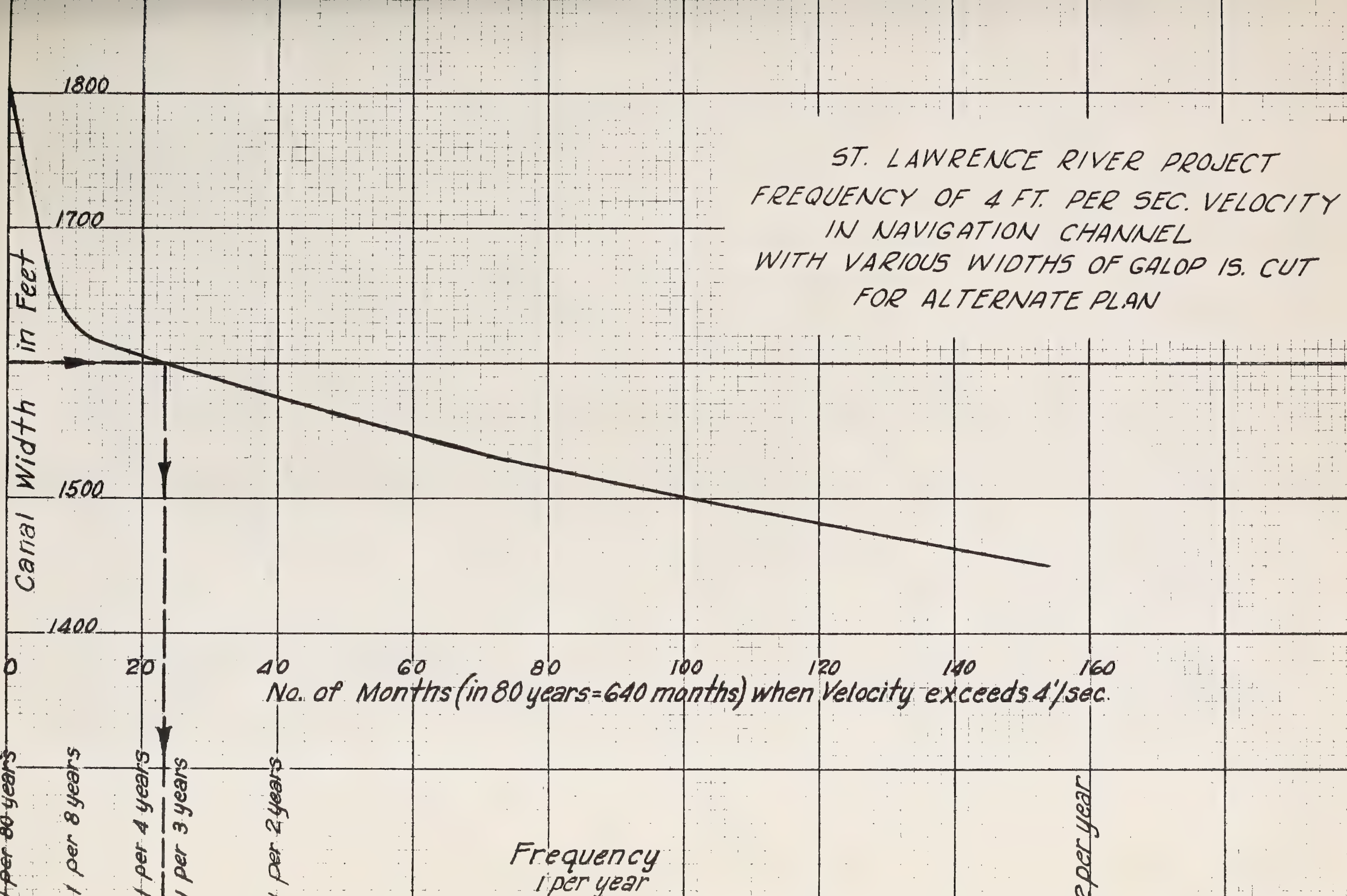


PLATE 13

PLATE 13

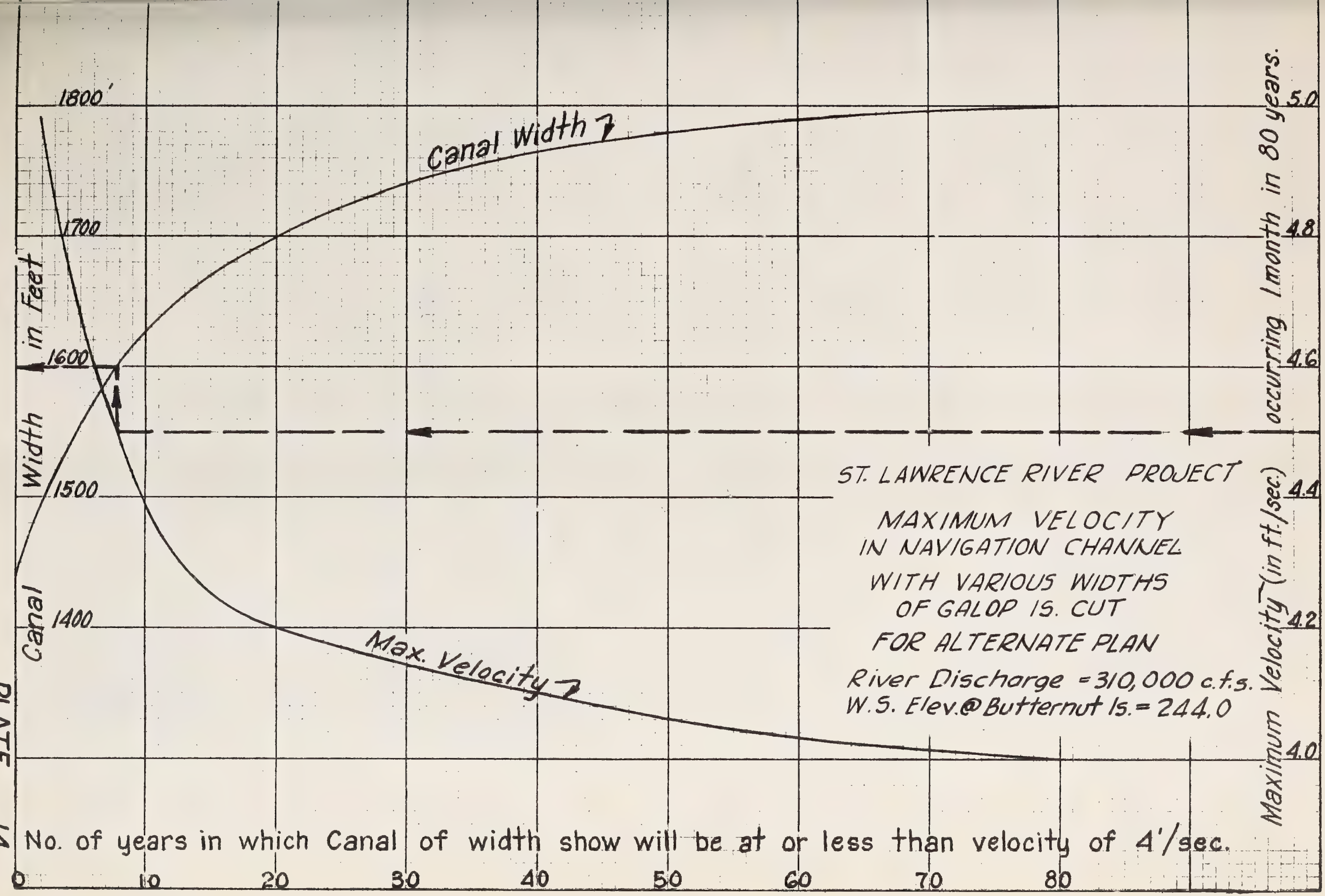
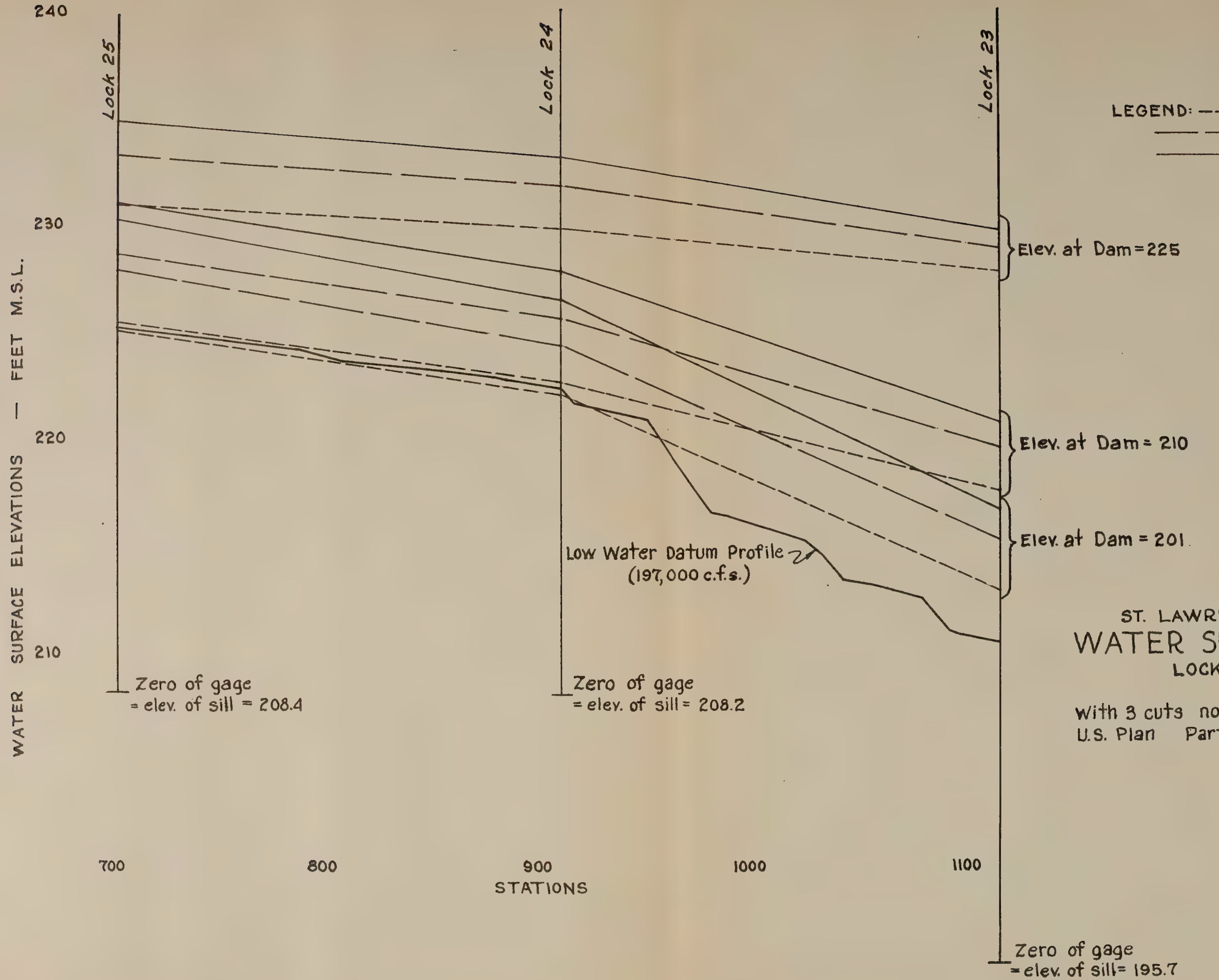


PLATE 14

PLATE 14



ST. LAWRENCE RIVER PROJECT

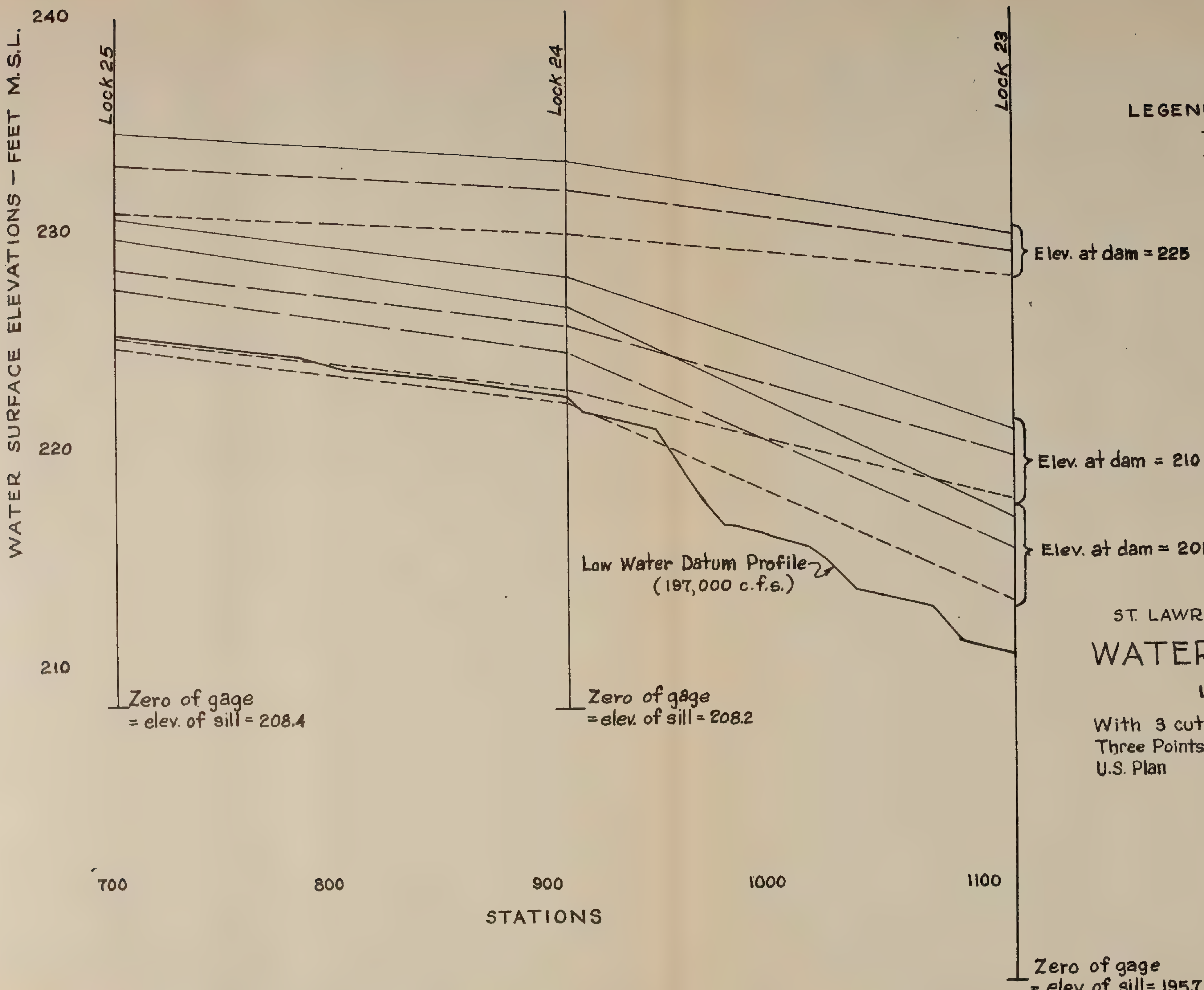
WATER SURFACE PROFILES

LOCK 25 TO LOCK 23

With 3 cuts north side of Ogden Is. only
U.S. Plan Partially raised pool.

H.A.K.
3-2-42

QC-1-4/1
Plate 15



LEGEND: ---- 197,000 c.f.s.
— — 247,000 c.f.s.
—— 280,000 c.f.s.

ST. LAWRENCE RIVER PROJECT

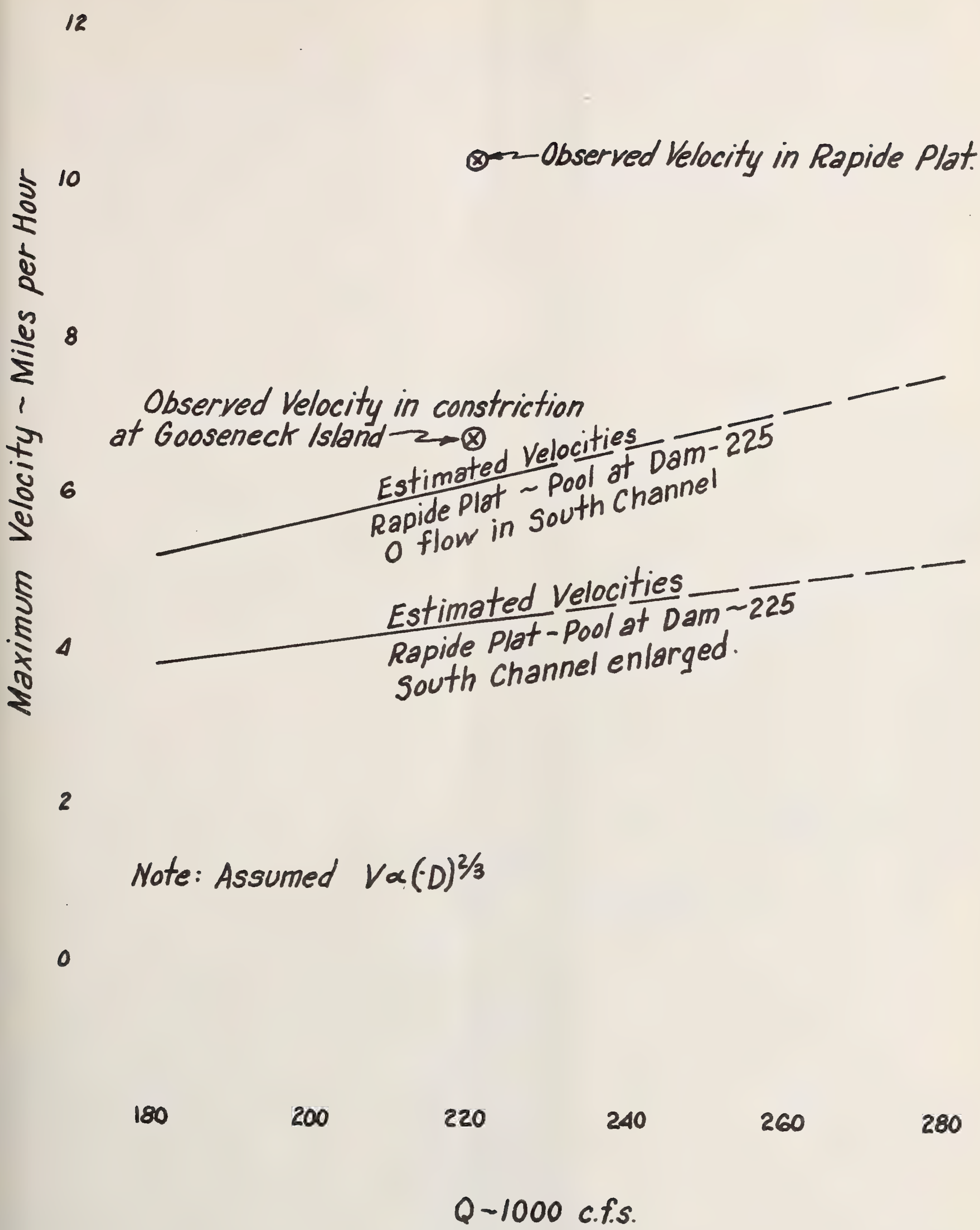
WATER SURFACE PROFILES

LOCK 25 TO LOCK 23

With 3 cuts north side of Ogden Is. & Point Three Points cut only.
U.S. Plan Partially raised pool.

H. A. K.
3-2-42

QC-1-4/2
Plate 16



COMPARATIVE MAXIMUM VELOCITIES
RAPIDE PLAT

BD-A-1/13
PLATE 17

WATER ELEVATIONS			
Gage No.	For Discharge of 216 000	247 000	280 000
1	243.88	245.25	
2	243.21	244.58	
3	242.07	243.42	
4	240.61	242.86	
5	238.54	239.18	
6	235.36	235.38	
7	231.4	233.1	235.1
8	242.96	244.37	
9	242.18	243.57	
10	242.68	244.61	
11	238.18	239.65	
12	236.87	238.46	
13	238.26	239.32	
14	235.13	236.88	
15	233.84	238.47	
16	233.8	234.8	237.1
17	231.8	233.2	236.2
18	230.4	231.9	233.8
19	230.2	231.3	233.6

ST. LAWRENCE WATERWAY
INTERNATIONAL RAPIDS SECTION
PLAN SHOWING
CURRENT FLOW LINES
CHIMNEY PT. TO PT. ROCKWAY
MILE TO MILE
SCALE OF FEET
General Engineering Branch Department of Transport

GC-1-531/1

PLATE 18

PROVINCE OF ONTARIO
STATE OF NEW YORK
IROQUOIS
MORRISBURG
WADDINGTON
Point Rockway
OGDEN ISLAND
CLARK ISL.
MURPHY ISLAND
CAN. NAT. RY.
ST. LAWRENCE R. R.
LEGEND:
Limits of Main Current
Secondary Currents
Speed in M.P.H
Boils, turbulence
REMARKS:
Work done June 2 & 3, 1941.
Sketched by C Rich
Launchmen-Haugen & C. Lochrem.
The discharge during this period was approximately 220,000 C.F.S.
ST. LAWRENCE WATERWAY
INTERNATIONAL RAPIDS SECTION
PLAN SHOWING
CURRENT FLOW LINES
PT. ROCKWAY TO GOOSE NECK ISL.
MILE TO MILE
SCALE OF FEET
General Engineering Branch Department of Transport
WC-1-531/2
PLATE 19

PROVINCE OF ONTARIO
FARRAN POINT
AULTSVILLE
E. WILLIAMSBURG
GOOSE NECK ISLAND
CROIL ISLAND
LOUISVILLE LANDING
STATE OF NEW YORK
LEGEND
Limits of Main Current
Secondary Currents
Speed in M P H
Boils, turbulence
REMARKS
Work done June 3, 1941
Sketched by C Rich
Launchmen-Haugen & C. Lochrem
The discharge during this period was approximately 220,000 C.F.S
ST. LAWRENCE WATERWAY
INTERNATIONAL RAPIDS SECTION
PLAN SHOWING
CURRENT FLOW LINES
GOOSE NECK ISL. TO CROIL ISLAND
MILE TO MILE
SCALE OF FEET
General Engineering Branch, Department of Transport.
LC-1-531/3
PLATE 20

PROVINCE OF ONTARIO
Hoople Creek
CAN NAT RY
WALES
MOULINETTE
DICKINSONS LANDING
CROIL ISLAND
SHEEK ISLAND
MILLE ROCHES
LONG SAULT ISLAND
BARNHART ISLAND
RICHARDS LANDING
INTERNATIONAL
MASSENA
GRASS
RIVER
STATE OF NEW YORK
LEGEND
Limits of Main Current
Secondary Currents
Speed in M P H
Boils turbulence
REMARKS
Work done June 12, 1941
Sketched by C Rich
Launchmen Haugen & C Jochtem
The discharge during this period was approximately 220,000 C F S
BC-1-531/4
PLATE 21
ST. LAWRENCE WATERWAY
INTERNATIONAL RAPIDS SECTION
PLAN SHOWING
CURRENT FLOW LINES
CROIL ISLAND TO MASSENA POINT
MILE TO MILE
SCALE OF FEET
General Engineering Branch Department of Transport

PROVINCE OF ONTARIO
CORNWALL
CAN PACIFIC RY
CAN NAT RY
HOG ISL
CORNWALL ISLAND
ST REGIS ISL
STATE OF NEW YORK
INTERNATIONAL BOUNDARY
Dead water
Slow current
LEGEND
Limits of Main Current
Secondary Currents
Speed in MPH
Boils, turbulence
REMARKS
Work done June 10, 1941
Sketched by C Rich
Launchmen-Haugen & C Backtrem
The discharge during this period was approximately 220,000 C F S
CC-1-531/5
PLATE 22
ST. LAWRENCE WATERWAY
INTERNATIONAL RAPIDS SECTION
PLAN SHOWING
CURRENT FLOW LINES
MASSENA PT TO LAKE ST FRANCIS
MILE TO MILE
SCALE OF FEET

PART TWO - EXHIBIT I

LAKE ONTARIO

LEVELS, OUTFLOWS, SUPPLIES

AND

REGULATION

General Engineering Branch,
Dept. of Transport,
Ottawa, September, 1940.

LAKE ONTARIO LEVELS, OUTFLOWS, SUPPLIES AND REGULATION

INDEX

INDEX

TABLES (Cont'd).

PLATES

LAKE ONTARIO LEVELS, OUTFLOWS, SUPPLIES AND REGULATION

WATER LEVELS

1. Records Available. The actual monthly mean water surface elevations of Lake Ontario at Oswego, N. Y., since 1860, are shown in Table No. 1. They are as recorded by the United States Lake Survey at Oswego, N. Y., and depend upon Bench Mark "A " at Oswego at elevation 251.898 feet above mean tide at New York, level adjustment of 1935.

2. Changes in Lake Level. Plate No. 9 shows the relationship between the water level of Lake Ontario at Oswego and the outflow from the Lake. The method of determining this relationship is discussed hereinafter in paragraph No. 6. This relationship has not been constant since 1860 but has been changed by construction operations and changes in the upper entrance to the Galops Canal, the deepening of the North Channel and the construction of the Gut Dam between Galops and Adams Island.

3. Lake Levels under Present Conditions. If conditions of supply to the Great Lakes - St. Lawrence Basin, as occurred in the past, should be repeated in the future, and if the diversion from the Great Lakes Basin through the Chicago Sanitary District Canal should be constant at 3,200 c.f.s. (see paragraph No. 11), the water levels of Lake Ontario would not be as in the past but would be raised as shown by the discharge stage - relationship as now exists. Table No. 2 shows the monthly mean water levels of the lake as they would be under present outlet conditions and with a continuous diversion of 3,200 c.f.s. at Chicago.

4. Data re - Water Levels. The following Table is a summary of the data given in detail in Tables Nos. 1 and 2.

Data re Water Levels of Lake Ontario

	Water Levels at Oswego	
	Actual	With outlet conditions as at present and with continuous diversion of 3,200 c.f.s.
Mean water level elevation	245.96	246.34
Minimum monthly mean (Nov. 1934)	242.68	242.93
Minimum daily mean (Nov. 26, 1934)	242.50	242.75
Maximum monthly mean (May, 1870)	249.02	249.66
Maximum daily mean (May 1, 1870)	249.19	249.83
Minimum yearly mean (1935)	243.54	243.78
Maximum yearly mean	247.63 (1886)	248.21 (1870)
	Number of Months	
No. of months above elevation 249.50	0	2
" " " " " 249.00	1	8
" " " " " 248.50	9	40
" " " " " 248.00	45	85

	Number of Months	
No. of months below elevation 244.50	99	53
" " " " " 244.00	39	26
" " " " " 243.50	18	10
" " " " " 243.00	5	3

5. The average monthly mean water levels in ten year periods and for the period 1860 to 1939 are also shown on Plate No. 1.

OUTFLOWS

6. Flow Measurements. The actual monthly mean outflows from Lake Ontario for the period 1860 to 1939 inclusive have been determined from discharge - stage relationships at the various locks along the International Rapids Section of the St. Lawrence River as established from flow measurements made since 1911 by the United States Lake Survey and the Departments of Railways and Canals and of Public Works of Canada. In all, 445 flow measurements are available, covering a range of flow from 175,000 c.f.s. to 277,000 c.f.s.

7. Discharge - Stage Relationships. As the relationship between water level and discharge at Lock 25 has been constant since 1904, a discharge - stage relationship at that point for the period 1904 to date was first established. All but 13 of the flow measurements fall within lines of 2½ per cent variation from the curve finally adopted for this relationship.

8. Discharge - Stage relationships at the other locks and at Oswego, N. Y., for various periods were established from gauge relationships.

9. The discharge - stage relationships at the various points are shown on the following Plates.

Lock No. 21	-	Plate No. 3.
" " 23	-	" " 4.
" " 24	-	" " 5.
" " 25	-	" " 6.
" " 27	-	" " 7.
" " 28	-	" " 8.
Oswego, N. Y.	-	" " 9.

10. Determination of Monthly mean Outflows. Having established discharge - stage relationship at the various locks, the monthly mean discharges were determined from these relationships for each lock. When the discharge obtained from the various locks agreed within one per cent, the average value was adopted as the monthly mean discharge except for January, February, and March, when a reduction of 6 per cent was made for ice retardation. When the discharge derived for any one lock showed a variation from the mean greater than one per cent, the results were checked and if no apparent reason for the variation could be found, that discharge, as determined by the gauge at the lock for that month, was ignored. It should be noted that the water levels at the various locks previous to 1917, when the first automatic gauges were established at Locks 24 and 25, were based on staff gauges read once a day only.

11. Diversions from Great Lakes Basin by Chicago Sanitary District. Since 1900 the diversion of water from the Great Lakes Basin through the Chicago Sanitary District Canal has reduced the outflow from Lake Ontario by the amount diverted. This diversion has varied from a monthly mean of 1,400 c.f.s. in January, 1900, to 10,800 c.f.s. in June, 1924. Under the United States Supreme Court Decree of April 21, 1930, the Chicago Sanitary District and the State

of Illinois were required to reduce the annual average diversion (exclusive of domestic pumpage) to 1,500 c.f.s. by December 31, 1938. The average annual domestic pumpage since 1929 has varied from 1,602 c.f.s. in 1935 to 1,712 c.f.s. in 1936. The average for 1938 was 1,605 c.f.s. According to the last report of the Sanitary District to the Supreme Court made in pursuance to the provisions of the Decree of 1930, the diversion, exclusive of domestic pumpage, is down to that permitted, i.e., 1,500 c.f.s. Assuming an average domestic pumpage of 1,700 c.f.s., the average diversion from the Great Lakes Basin at Chicago in the future can be taken as 3,200 c.f.s.

12. Data re - Outflows. Table No. 3 shows the monthly mean outflows from Lake Ontario for the period 1860 to 1939, under actual conditions, and Table No. 4 shows the same data assuming a continuous diversion of 3,200 c.f.s. at Chicago. The following Table is a summary of the data given in Tables Nos. 3 and 4.

Data re - Outflows from Lake Ontario

	Outflows in 1,000 c.f.s. Actual	Outflows in 1,000 c.f.s. Assuming continuous diversion of 3,200 c.f.s.
Mean outflow - 1860 - 1869	261	258
1870 - 1879	249	246
1880 - 1889	252	249
1890 - 1899	231	228
1900 - 1909	237	238
1910 - 1919	233	238
1920 - 1929	224	229
1930 - 1939	207	211
Mean 1860 - 1939	237	237
Minimum monthly mean (Feb. 1936)	144	148
Maximum monthly mean (May 1862 and 1870)	314	311
Minimum yearly mean (1934)	181	186
Maximum yearly mean (1861)	281	277
Monthly mean flow 75% of time	217	218
" " " 35% " "	249	249
" " " 20% " "	262	263
	Number of months	
No. of months above 300,000 c.f.s.	12	9
" " " " 290,000 "	36	30
" " " " 280,000 "	71	69
No. of months below 210,000 c.f.s.	185	178
" " " " 200,000 "	122	112
" " " " 190,000 "	59	55
" " " " 180,000 "	23	20

13. The average monthly mean outflows in ten year periods and for the period 1860 to 1939 are also shown on Plate No. 2.

SUPPLIES

14. Monthly Mean Net Supplies. The total net supply to the lake for any month is the total outflow corrected for the gain or loss of storage in the lake.

15. On account of the oscillation of the lake surface, the water level on any day does not give the true lake level for that day. For the purposes of determining the monthly gain or loss of storage, the elevation of the lake at the first of each month has been taken as the mean of the monthly mean levels of the given and preceeding months.

16. Data re - Supplies. Average monthly mean supplies in ten year periods and minimum and maximum monthly and yearly mean actual net periods and maximum monthly and yearly mean actual net supplies are given in Table No. 5. Monthly mean supplies for the period 1860 to 1939, assuming a continuous diversion of 3,200 c.f.s. at Chicago and 5,000 c.f.s. added from the Ogoki River and Long Lac are given in Table No. 6.

Data re - Supplies to Lake Ontario

	Supplies in 1,000 c.f.s.	
	Actual	Assuming continuous diversion of 3,200 c.f.s. and 5,000 c.f.s. added.
Mean - 1860 -1939	236	242
Minimum monthly mean (Jan. 1936)	148	156
Maximum monthly mean (April 1870)	364	366
Minimum yearly mean (1934)	177	187
Maximum yearly mean (1861)	286	288

REGULATION OF DISCHARGE AND LEVELS OF LAKE ONTARIO

17. Basic Assumption re Supply. The Joint Board of Engineers in their Report on the St. Lawrence Waterway Project of 1926, presented a program of "Regulation of Lake Ontario Only" based on the assumption of a continuous diversion of 8,500 c.f.s. through the Chicago Drainage Canal. Due to the limitations placed on this diversion by the United States Supreme Court Decree of April 21, 1930, the total diversion, including water required for domestic pumpage, may now be assumed as 3,200 c.f.s.

18. The diversion of water from the Ogoki River and Long Lac watersheds into Lake Superior, as contemplated by Ontario, will mean an addition to the net supply to the Great Lakes which may be taken at 5,000 c.f.s.

19. The Method of Regulation discussed hereinafter is based on the above assumptions; i.e., a continuous diversion at Chicago of 3,200 c.f.s. and an addition to the net supply to the Great Lakes of 5,000 c.f.s. This means an additional net supply of 10,300 c.f.s. as compared with the supply assumed by the Joint Board of Engineers. Monthly mean supplies for the period 1860 - 1939 based on the above assumptions are given in Table No. 6.

20. Requirements of Regulation. In the Method of Regulation presented herein an attempt was made to meet the following requirements:-

(a) To keep the fluctuations of the levels of Lake Ontario within that would have resulted in the past, assuming a continuous diversion of 3,200 c.f.s. at Chicago and present outlet conditions.
(b) To maintain, without impairment, the low water levels of Montreal Harbour.
(c) To maintain low flows during the winter period December 15 to March 31, in order that the difficulties of winter power operation may not be aggravated.
(d) To maintain flows during the first half of April no greater than would naturally occur, in orderto avoid the danger of aggrevating the spring rise during the breakup of the ice below Montreal.
(e) To avoid any material increase in the amount and duration of the high discharges during May, in order not to aggravate high water levels in Lake St. Louis during the Ottawa floods.
(f) To keep the fluctuation in monthly mean discharges within the limits as existed in nature.
(g) To hold back the natural excess outflow during the early summer months, in order to raise the ordinary levels of Lake Ontario.
(h) To secure the maximum dependable flow throughout the year for power operation.

21. Various rule curves for regulations were studied and applied to conditions as existed in the past in an attempt to meet all of the above requirements. One rule may completely satisfy some of the requirements at a sacrifice in the degree to which others are met. Of all the methods and variations thereof that were studied, Method No. 5 seemed the best to meet all conditions. This Method was tested by application of the Rule Curve to conditions of supply as existed during the past 80 years, i.e., 1860 to 1939, assuming a continuous diversion at Chicago of 3,200 c.f.s., and addition to the net supply of 5,000 c.f.s. from Ogoki and Long Lac.

22. Results Obtained by Regulation. The results obtained by application of the Rule Curve to conditions as existed in the past, and the degree with which the Method of Regulation meets the requirements of an ideal regulation as set forth above, are discussed hereinafter.

23. Requirement (a). "To keep the fluctuations of the levels of Lake Ontario within the levels that would have resulted in the past assuming a continuous diversion of 3,200 c.f.s. at Chicago and present outlet conditions."

24. The following Table shows the actual levels of Lake Ontario, the levels as would have existed with a continuous diversion of 3,200 c.f.s. at Chicago and with existing outlet conditions and the levels that would have resulted from the application of the Method of Regulation.

MONTHLY MEAN LAKE LEVELS

	IN NATURE		UNDER REGULATION
	Actual	Continuous diversion of 3,200 c.f.s. and present outlet conditions	
Monthly Mean Water Levels of Lake Ontario at Oswego, N. Y.			
Maximum	249.02	249.66	249.10
Minimum	242.68	242.93	243.77

Minimum during navigation season	242.68	242.93	244.03
		NUMBER OF MONTHS	
Total Period.			
Above elev. 249.5	0	2	0
" " 249.0	1	8	3
" " 248.5	9	40	14
" " 248.0	45	85	50
Below elev. 244.5	99	53	17
" " 244.0	39	26	3
" " 243.5	18	10	0
" " 243.0	5	3	0
Navigation Season Only.			
Below elev. 244.5	40	23	4
" " 244.0	18	11	0
" " 243.5	7	4	0
" " 243.0	2	1	0

25. The above Table shows that the Method presented meets requirement (a) in all respects. The maximum monthly mean water level would occur in May, 1870. This can be reduced by increasing the permissible discharges during April and May which would, however, conflict with requirements (d), (e) and (f). The minimum monthly mean level can be raised by decreasing the discharge at a sacrifice in the degree to which requirement (h) is satisfied.

26. Requirement (b). "To maintain, without impairment, the low water levels of Montreal Harbour."

27. During the period 1880 to 1939 inclusive, the monthly mean water levels in Montreal Harbour have been below the elevation of the low water datum of 1897 (elev. 18.99) 32 times, the minimum monthly mean elevation being 17.15 which was the mean in November, 1934. Changes in the channel below Montreal since 1894, by enlargements and obstructions, however, have lowered the level in the Harbour for the same discharge conditions and if channel conditions as now exist had been in existence throughout the period since 1880, the monthly mean water levels would have been below the elevation of low water datum 46 times.

28. The following Table shows the actual conditions in the Harbour, the conditions as would have existed with a continuous diversion of 3,200 c.f.s. at Chicago and present channel conditions, and the conditions that would have resulted from the application of Method No. 5 of Regulation.

WATER LEVELS IN MONTREAL HARBOUR

	IN NATURE		UNDER REGULATION
	Actual Conditions	With continuous diversion of 3,200 c.f.s. & with present channel conditions	
Minimum monthly mean elev.	17.15	17.37	17.60

	Number of Months		
Below elev. 18.99	32	37	26
18.50	13	16	12
18.00	8	8	6
17.50	3	1	0

29. The above Table shows that requirement (b) is met in all respects. The minimum monthly mean level occurred in November, 1934. This level could be raised by increasing the discharge which would lower the level of Lake Ontario and conflict with requirement (a).

30. Requirement (c). "To maintain low flows during the winter period from December 15th to March 31st, in order that the difficulties of winter operation may not be aggravated."

31. In the project proposed for the improvement of the International Rapids Section, the channel enlargement to be provided below Lotus Island is designed to give a maximum mean velocity in any cross-section not exceeding 2.25 feet per second with the flow, and at the stage, to be permitted on the 1st of January of any year under the regulation of outflows and levels of Lake Ontario. Application of Method of Regulation No. 5 would produce flows in January that would result in velocities not greater than 2.25 f.s. with the channel enlargements shown on the plans of the proposed project for improvement. Also, the flows that would occur in February and March would not set up velocities detrimental to winter operation.

32. Requirement (d). "To maintain flows during the first half of April no greater than would naturally occur, in order to avoid the danger of aggravating the Spring rise during the breakup of the ice below Montreal."

33. This requirment is the same as one set out by the Joint Board of Engineers in their Report of 1926. The increase in the extent of the operation of the ice breakers below Montreal has decreased the importance that should be attached to meeting this requirement. The result of the application of the Method of Regulation on the flow during the first half of April, as compared with conditionsin nature, however, are shown in the following Table.

	Maximum Discharge during First Half of April
In nature.	
Actual	290,000 c.f.s.
With continuous diversion of 3,200 c.f.s.	287,000 C.f.s.
Under Regulation	287,000 c.f.s.

34. Requirement (e). "To avoid any material increase in the amount and duration of the high discharges during May in order not to aggravate high water levels in Lake St. Louis during the period of Ottawa River floods."

35. This requirement is not as hard to meet now as it was when the Joint Board of Engineers studied the question in 1926 as since that time storage works on the Gatineau, Lievre and Ottawa rivers have provided means whereby the flood flows of the Ottawa River have been decreased. This decrease in the Ottawa flood discharges can be taken at 30,000 c.f.s. of which the decrease into Lake St. Louis can be taken at 15,000 c.f.s.

36. The following Table gives a comparison of the water levels of Lake St. Louis during May Under various conditions:-

MONTHLY MEAN WATER LEVELS OF LAKE ST. LOUIS DURING MAY

	IN NATURE		UNDER REGULATION
	Actual	With continuous diversion of 3,200 c.f.s. & outlet conditions of Lake St. Louis as at present	Assuming 30,000 c.f.s. storage on Ottawa River Watershed
Maximum monthly mean W. L.	72.93	73.93	73.75
2nd Highest monthly mean W. L.	72.64	73.34	72.50
		Number of Times	
Above elev. 71.0	20	26	21
" " 72.0	6	10	7
" " 73.0	0	2	1

37. Method No. 5 meets the requirements both in regard to maximum monthly mean water level and times of occurrence. The maximum level is reached in May, 1876, when the total monthly mean discharge in the Ottawa River was 322,500 c.f.s. or 25% greater than the next highest monthly mean on record.
38. Requirement (f). "To keep the fluctuation in monthly mean discharges within the limits as existed in nature."
39. The following Table shows the range in monthly mean discharges as actually occurred, as would have occurred with a continuous diversion of 3,200 c.f.s. and as would have occurred had the Method of Regulation been in operation.

MONTHLY MEAN DISCHARGES
(in 1,000 c.f.s.)

	IN NATURE		UNDER REGULATION
	Actual	Continuous diversion of 3,200 c.f.s.	
Maximum	314	311	310
Minimum	144	148	180
35% of time	249	249	253
65% of time	226	227	223
		Number of Months	
At maximum	2	2	44
300 and above	12	9	59
Below 200	122	112	44
" 190	59	55	15
" 180	23	20	0

40. From the above, it will be seen that the range in monthly mean discharges is well within that which occurred in nature. The number of occurrences of flows above 300,000 c.f.s. is greatly increased over that in nature but this is unavoidable if requirement (c), limiting the flows in winter, and require-

ment (a), limiting lake levels, are met. The lower limit of discharge is greatly increased and the number of occurrences below 200,000 c.f.s. is greatly decreased under Regulation.

41. It will be noted that the rule curve designates a lower discharge during January and February than during other months for lake levels below elev. 244.50. The discharge during these two months at this low lake level could be increased to that designated by the line on the rule curve for the rest of the year without any great loss in lake level, but as is pointed out under the discussion on "Requirement (h)" hereinafter, the power available during these two months is greater with the lower flow.

42. Requirement (g). "To hold back the natural excess outflow during the early summer months, in order to raise the ordinary levels of Lake Ontario."

43. The Table in paragraph 24 shows the effect on the low water levels of Lake Ontario resulting from the application of the Method of Regulation. The increase in low water level and the decrease in the number of times during which the water level would have fallen below elevation 244.5 are the result of holding back the natural excess outflow during the early summer months.

44. Requirement (h). "To secure the maximum dependable flow throughout the year for power operation."

45. If it were possible to prophecy conditions accurately for years ahead, the greatest minimum flow possible, assuming a continuous diversion of 3,200 c.f.s. at Chicago, 5,000 c.f.s. added from the Ogoki River and Long Lac and Lake Ontario levels held between elevations 249.00 and 244.30 would be only 198,000 c.f.s. This maximum would be set by the supply to the lake between July, 1933, and February, 1936, which averaged only 186,600 c.f.s. (See Table No. 7).

46. If the average outflow from Lake Ontario, assuming 3,200 c.f.s. diverted and 5,000 c.f.s. added, i.e., 242,000 c.f.s., were to be discharged continuously during the period 1860 to 1939 inclusive, about 75 feet of storage would be required on Lake Ontario.

47. The minimum monthly mean flow that would have occurred under regulation is 180,000 c.f.s. and the flow would have been below 198,000 c.f.s. only 4% of the time.

48. The firm power available is not directly proportioned to the minimum flow available, as an increased minimum flow would result in a lower lake level and increased friction losses between the lake and the powerhouse headworks. Backwater calculations, with ice covered river conditions, show the maximum power available with the lake level at elevation 244.00 would be with a flow of 187,000 c.f.s. It is for this reason that the rule curve for discharges during January and February designates a lower flow than for the same lake level during the other months of the year.

49. Table No. 8 shows the monthly mean discharges resulting from the application of the rule curve for Regulation Method No. 5 to the period 1860 to 1939. Table No. 9 shows similar data in regard to Lake Ontario Levels.

50. A comparison of discharges under natural conditions and under Regulation are shown on Plate No. 10. Similar data in regard to Lake Levels are shown on Plate No. 11. Monthly mean discharges and Lake Levels for the period 1860 to 1939 are shown on Plate No. 12.

51. Rule Curve. The rule curve on which the Method of Regulation is based is shown on Plate No. 13. The regulated discharge to be allowed in any month or half month is determined by applying to the rule curve for the month a level, to be determined as shown later, the discharge so determined to be modified by a correction.

52. Correction to Rule Curve. In the regulation presented by the Joint Board, the correction applied to the discharge obtained from the rule curve was based on the level of Lake Huron. Due to the change in outlet capacity of the St. Clair River, the relation between the correction and lake level was not constant throughout the period 1860 to 1925 during which the method of regulation was tested. This relationship may change again in the future but if so, such a change could not be determined until some time had elapsed, and the result would be an application of correction which might give entirely wrong results.

53. A correction based on the outflow from Lake Huron was studied but an examination of the monthly mean discharges through the St. Clair and Detroit rivers in the past shows that the actual net supply to Lake Ontario, which is what has to be provided for, does not necessarily bear any direct relationship to the outflow from Lake Huron. After various trials, it was decided that a correction based on the net mean supply to Lake Ontario during the previous month gave the best results.

54. A correction to be applied to the discharge obtained from the Rule Curve is shown on Plate No. 14. The amount of the correction for any month was derived from the duration curve of total net monthly mean supply to Lake Ontario in which the "percent of time" scale was replaced by a scale representing the variation of the total net monthly mean supply from 50% of the time. For supplies greater than those occurring 50% of the time the correction is positive, and for those less than 50% of the time it is negative. The corrections are to be added algebraically to the discharges obtained from the Rule Curve. Certain limitations as regards the application of the correction are shown on the Rule Curve.

55. Method of Determining Discharge. In the method of regulation submitted by the Joint Board, the correction was applied to the discharge obtained from the rule curve, and the resulting level of Lake Ontario at the end of the month was used to enter the rule curve for the next month's discharge. This method of application resulted largely in the correction cancelling itself, since a positive correction lowered the lake level at the end of the month which resulted in a lower discharge for the next month from the rule curve, and conversely for a negative correction. In order to obtain the full benefits of a correction it was found necessary to apply it in such a way that its effect would be cumulative for some period such as an entire year.

56. The computations determining the monthly discharges during a typical year are shown in Table No. 10. The method used can be followed by reference to this Table and the description attached thereto.

G. A. Lindsay,
Engineer-in-Charge,
General Engineering Branch,
Dept. of Transport.

Ottawa, Ont.,
September, 1940.

LAKE ONTARIO

MONTHLY MEAN WATER LEVELS

AT

OSWEGO, N. Y.

Elevations above mean tide at New York depend
upon B.M.A. at Oswego at 251.898 feet.
Level Adjustment of 1935.

(Obtained from U.S.L.S.Office, Detroit, Feb. 1940)

General Engineering Branch,
Dept. of Transport,
June, 1940.

F.E.102.20

TABLE No. 1 Cont'd

LAKE ONTARIO

MONTHLY MEAN WATER LEVELS AS IN NATURE

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	246.17	246.16	246.38	246.89	247.47	247.78	247.71	247.35	246.95	246.64	246.44	246.36	246.85
70-79	5.71	5.73	5.95	6.64	6.96	6.98	6.94	6.66	6.22	5.87	5.59	5.53	6.23
80-89	5.89	6.04	6.36	6.81	7.12	7.31	7.33	7.03	6.60	6.22	5.98	5.95	6.55
90-99	4.91	5.05	5.35	5.87	6.11	6.29	6.15	5.81	5.40	5.00	4.78	4.70	5.45
1900-09	5.34	5.41	5.69	6.41	6.69	6.79	6.83	6.60	6.17	5.80	5.51	5.36	6.05
10-19	5.38	5.47	5.67	6.36	6.70	6.93	6.85	6.54	6.19	5.83	5.64	5.48	6.09
20-29	5.05	5.02	5.27	5.89	6.24	6.30	6.25	5.99	5.59	5.31	5.03	5.18	5.60
30-39	4.25	4.45	4.73	5.31	5.62	5.65	5.52	5.16	4.74	4.36	4.09	3.94	4.82
Mean	5.34	5.42	5.68	6.27	6.61	6.75	6.70	6.52	5.98	5.63	5.38	5.31	5.96
Minimum monthly means	242.90 (1935)	242.82 (1936)	243.31 (1935)	243.61 (1935)	243.90 (1935)	244.14 (1935)	243.99 (1934)	243.50 (1934)	243.17 (1934)	242.95 (1934)	242.68 (1934)	242.71 (1934)	
Maximum monthly means	247.63 (1886)	247.70 (1886)	247.84 (1886)	248.46 (1886)	249.02 (1870)	248.70 (1870)	248.70 (1862)	248.36 (1862)	247.68 (1862)	247.78 (1861)	247.85 (1861)	247.64 (1861)	
Minimum yearly mean 1935	242.90	243.05	243.31	243.61	243.90	244.14	244.32	244.06	243.66	243.29	243.13	243.09	243.54
Maximum yearly mean 1886	247.63	247.70	247.84	248.46	248.68	248.44	248.07	247.62	247.27	246.86	246.54	246.47	247.63

General Engineering Branch,
Dept. of Transport,
June, 1940.

F.H. 102.20

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO IN NATURE

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860	246.64	246.68	246.78	246.82	247.06	247.53	247.90	247.32	246.87	246.68	246.77	246.78	246.99
1	6.51	6.52	7.01	7.16	8.12	8.55	8.32	8.12	7.61	7.78	7.85	7.64	7.60
2	7.19	6.73	7.10	7.95	8.90	8.64	8.70	8.36	7.68	6.73	6.79	6.63	7.52
3	6.75	6.84	6.91	7.55	8.11	8.22	7.85	7.32	7.00	6.75	6.59	6.61	7.21
4	6.33	6.20	6.27	6.79	7.77	8.21	7.91	7.45	6.94	6.61	6.60	6.70	6.98
5	7.07	7.25	7.40	7.49	7.68	7.69	7.61	7.05	6.41	6.14	5.86	5.72	6.95
6	5.49	5.52	5.47	5.96	6.15	6.84	6.85	6.77	6.68	6.61	6.29	6.25	6.24
7	6.02	5.85	6.51	7.49	8.11	8.52	8.17	7.58	7.04	6.46	5.71	4.94	6.87
8	4.45	4.55	4.82	5.54	6.00	6.61	6.48	6.19	6.03	5.48	5.17	5.39	5.56
9	5.29	5.39	5.55	6.11	6.77	7.01	7.32	7.40	7.19	7.13	6.76	6.89	6.57
Mean	6.17	6.16	6.38	6.89	7.47	7.78	7.71	7.35	6.95	6.64	6.44	6.36	6.85
1870	247.22	247.42	247.37	248.24	249.02	248.70	248.38	248.01	247.34	247.01	246.51	246.21	247.62
1	6.09	5.92	6.12	6.70	7.16	7.09	6.94	6.49	6.15	5.65	5.24	4.93	6.21
2	4.76	4.54	4.38	4.90	5.00	5.25	5.40	5.25	4.90	4.75	4.65	4.38	4.85
3	4.29	4.40	4.53	6.43	6.99	6.94	6.90	6.61	6.18	5.76	5.65	5.82	5.88
4	6.39	6.77	7.32	7.23	7.20	7.31	7.25	7.00	6.57	5.96	5.43	5.06	6.61
5	4.75	4.41	4.68	5.44	5.73	5.90	5.96	5.78	5.58	5.30	5.13	4.93	5.30
6	5.32	6.00	6.55	7.53	8.10	8.32	8.39	7.94	7.33	7.00	6.64	6.43	7.13
7	5.94	5.66	5.81	6.49	6.57	6.45	6.48	6.23	5.80	5.40	5.28	5.41	5.96
8	5.51	5.71	6.41	6.67	7.01	6.99	6.95	6.91	6.62	6.36	6.24	7.03	6.53
9	6.83	6.49	6.36	6.73	6.84	6.84	6.70	6.34	5.94	5.50	5.13	5.14	6.24
Mean	5.71	5.73	5.95	6.64	6.96	6.98	6.94	6.66	6.22	5.87	5.59	5.53	6.23

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OGSWEGO IN NATURE

YEAR	JAN.	FEB.	MAR.	APR	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	245.33	245.66	245.98	246.18	246.36	246.56	246.55	246.12	245.77	245.39	245.33	245.13	245.86
1	4.76	4.75	5.42	5.83	6.02	6.23	6.33	6.01	5.42	5.22	5.22	5.23	5.54
2	5.76	5.94	6.55	6.84	7.05	7.58	7.56	7.22	6.84	6.33	5.90	5.65	6.60
3	5.33	5.38	5.63	6.18	6.82	7.52	8.06	7.87	7.40	6.97	6.72	6.59	6.71
4	6.54	6.94	7.61	8.19	8.22	8.12	8.02	7.67	7.25	6.83	6.33	6.18	7.35
5	6.18	5.91	5.62	6.30	7.10	7.47	7.61	7.47	7.23	7.05	7.10	7.27	6.86
6	7.63	7.70	7.84	8.46	8.68	8.44	8.07	7.62	7.27	6.86	6.54	6.47	7.63
7	6.19	6.95	7.46	7.67	8.23	8.19	7.91	7.41	6.79	6.40	6.05	5.78	7.09
8	5.48	5.33	5.57	6.20	6.34	6.31	6.37	6.27	5.88	5.52	5.44	5.44	5.85
9	5.65	5.80	5.96	6.20	6.35	6.66	6.85	6.60	6.10	5.60	5.21	5.75	6.06
Mean	5.89	6.04	6.36	6.81	7.12	7.31	7.33	7.03	6.60	6.22	5.98	5.95	6.55
1890	246.25	246.59	246.96	247.16	247.51	248.15	247.98	247.32	246.96	246.63	246.70	246.50	247.06
1	6.18	6.44	6.98	7.46	7.23	6.82	6.54	6.10	5.67	5.03	4.43	4.42	6.11
2	4.50	4.47	4.60	5.19	5.24	5.80	6.32	6.24	6.03	5.59	5.31	5.19	5.37
3	4.86	4.76	5.24	5.98	7.12	7.36	7.09	6.56	6.30	5.77	5.36	5.22	5.97
4	5.55	5.74	6.04	6.09	6.26	6.79	6.59	6.02	5.50	5.25	4.94	4.56	5.78
5	4.49	4.43	4.32	4.86	4.99	4.88	4.58	4.34	3.99	3.66	3.40	3.42	4.28
6	3.79	4.26	4.48	5.40	5.42	5.33	5.07	4.93	4.45	4.22	3.96	3.98	4.61
7	3.86	3.82	4.29	4.95	5.40	5.61	5.60	5.59	5.09	4.46	4.40	4.46	4.79
8	4.63	5.07	5.47	5.91	6.06	6.12	5.84	5.50	5.08	4.83	4.87	4.89	5.36
9	4.97	4.87	5.13	5.68	5.93	6.06	5.91	5.45	4.95	4.52	4.42	4.35	5.19
Mean	4.91	5.05	5.35	5.87	6.11	6.29	6.15	5.81	5.40	5.00	4.78	4.70	5.45

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO IN NATURE

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	244.50	244.80	245.10	245.79	245.98	245.90	245.81	245.53	245.11	244.72	244.56	244.83	245.22
1	4.67	4.61	4.39	5.62	5.91	6.01	5.80	5.46	5.14	4.70	4.31	4.36	5.08
2	4.49	4.44	5.22	5.56	5.54	5.59	6.02	6.19	5.69	5.36	5.07	4.88	5.34
3	4.82	4.97	5.79	6.68	6.58	6.46	6.55	6.33	6.02	5.66	5.43	5.07	5.87
4	4.71	5.00	5.63	7.00	7.61	7.87	7.89	7.64	7.25	6.87	6.36	5.81	6.64
5	5.79	5.49	5.29	6.13	6.25	6.59	6.98	6.90	6.75	6.45	6.07	5.88	6.21
6	6.13	6.10	5.91	6.25	6.36	6.41	6.58	6.27	5.81	5.52	5.59	5.71	6.05
7	6.34	6.47	6.47	6.86	7.09	7.12	7.12	6.90	6.50	6.40	6.33	6.33	6.66
8	6.73	6.99	7.39	8.02	8.46	8.62	8.34	7.95	7.14	6.44	5.92	5.51	7.29
9	5.17	5.28	5.70	6.18	7.16	7.30	7.16	6.82	6.28	5.84	5.35	5.21	6.11
Mean	5.34	5.41	5.69	6.41	6.69	6.79	6.83	6.60	6.17	5.80	5.51	5.36	6.05
1910	244.94	245.03	245.75	245.97	246.42	246.46	246.29	246.05	245.70	245.38	245.15	244.89	245.67
1	4.77	4.86	4.96	5.44	5.60	3.66	5.54	5.19	4.88	4.62	4.50	4.63	5.05
2	4.76	4.87	5.10	6.32	6.82	7.34	7.01	6.66	6.38	6.17	6.08	6.11	6.13
3	6.51	6.75	6.71	7.86	7.97	8.02	7.83	7.31	6.74	6.29	6.06	5.91	7.00
4	5.60	5.87	5.67	6.75	6.95	6.91	6.72	6.33	6.09	5.59	5.25	4.83	6.05
5	4.70	4.99	5.27	5.04	5.15	5.12	5.13	5.43	5.45	5.17	4.94	4.78	5.10
6	5.05	5.41	5.46	6.40	7.13	7.86	7.93	7.36	6.69	6.06	5.65	5.37	6.36
7	5.26	5.08	5.17	6.24	6.51	6.98	7.46	7.35	6.93	6.68	6.69	6.65	6.42
8	6.07	5.98	6.61	7.17	7.13	7.01	6.85	6.43	6.20	6.00	6.00	5.89	6.44
9	6.09	5.91	6.01	6.43	7.27	7.95	7.75	7.33	6.86	6.35	6.11	5.74	6.65
Mean	5.38	5.47	5.67	6.36	6.70	6.93	6.85	6.54	6.19	5.83	5.64	5.48	6.09

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO IN NATURE

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	245.31	245.01	245.05	245.55	245.60	245.56	245.70	245.62	245.47	245.29	245.23	245.40	245.40
1	5.54	5.46	5.79	6.38	6.68	6.61	6.37	5.93	5.43	5.11	4.85	4.83	5.75
2	4.73	4.70	5.08	6.06	6.55	6.75	6.92	6.56	6.03	5.61	5.15	4.64	5.73
3	4.50	4.47	4.74	5.33	5.62	5.93	5.80	5.41	5.03	4.65	4.34	4.47	5.02
4	4.77	4.85	4.88	5.36	6.10	6.27	6.21	6.04	5.65	5.45	4.95	4.58	5.43
5	4.22	4.41	5.20	5.61	5.65	5.42	5.21	4.90	4.56	4.32	4.31	4.55	4.86
6	4.28	4.10	4.14	4.92	5.37	5.31	5.20	4.99	4.86	4.93	5.24	5.42	4.90
7	5.28	5.31	5.71	5.97	5.95	6.11	6.01	5.77	5.27	4.99	4.85	5.65	5.57
8	6.04	5.99	5.97	6.42	6.61	6.59	6.73	6.64	6.17	5.76	5.67	5.80	6.20
9	5.85	5.93	6.15	7.28	8.27	8.46	8.36	8.00	7.45	6.96	6.66	6.45	7.15
Mean	5.05	5.02	5.27	5.89	6.24	6.30	6.25	5.99	5.59	5.31	5.03	5.18	5.60
1930	246.65	247.05	247.66	247.99	248.07	248.11	248.09	247.46	246.85	246.24	245.65	245.30	247.09
1	4.94	4.75	4.67	4.97	5.13	5.43	5.27	4.89	4.59	4.24	4.00	3.94	4.74
2	4.35	5.05	5.26	5.82	6.14	6.05	5.90	5.59	5.04	4.57	4.38	4.30	5.20
3	4.33	4.31	4.27	4.85	5.32	5.45	5.17	4.77	4.36	3.85	3.44	3.37	4.46
4	3.59	3.68	3.68	4.27	4.48	4.24	3.99	3.50	3.17	2.95	2.68	2.71	3.58
5	2.90	3.05	3.31	3.61	3.90	4.14	4.32	4.06	3.66	3.29	3.13	3.09	3.54
6	3.03	2.82	3.47	5.01	5.25	5.07	4.77	4.23	3.98	3.82	3.76	3.49	4.06
7	3.97	4.65	4.84	5.01	5.82	6.04	6.03	5.75	5.34	4.82	4.81	4.65	5.14
8	4.46	4.74	5.26	5.80	5.95	5.86	5.69	5.67	5.24	5.03	4.70	4.44	5.24
9	4.32	4.37	4.91	5.74	6.15	6.06	5.94	5.71	5.19	4.81	4.39	4.15	5.15
Mean	4.25	4.45	4.73	5.31	5.62	5.65	5.52	5.16	4.74	4.36	4.09	3.94	4.82

LAKE ONTARIO

MONTHLY MEAN WATER LEVELS AT OSWEGO, N. Y.,
AS WOULD HAVE RESULTED IF OUTLET CONDITIONS
THROUGHOUT THE PERIOD HAD BEEN AS AT PRESENT
AND IF 3,200 C. F. S. HAD BEEN DIVERTED
CONTINUOUSLY AT CHICAGO

Note: Obtained from actual levels at Oswego, N.Y. (1935 adjustment) by correcting due to change in discharge capacity of outlet as shown on discharge - stage relation curve for Oswego (Diag. 76 F.H. 99). Correction for continuous diversion of 3,200 c.f.s. at Chicago based on increment in outflow of 20,000 c.f.s. per foot.

General Engineering Branch,
Dept. of Transport,
June, 1940.

F.H. 102.21

LAKE ONTARIO

MONTHLY MEAN WATER LEVELS ASSUMING OUTLET CONDITIONS AS AT PRESENT AND CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	246.76	246.73	246.96	247.46	248.05	248.37	248.30	247.93	247.51	247.21	247.01	246.93	247.43
70-79	6.31	6.32	6.55	7.21	7.55	7.56	7.51	7.23	6.80	6.46	6.18	6.14	6.82
80-89	6.36	6.51	6.83	7.28	7.59	7.78	7.81	7.49	7.08	6.67	6.44	6.41	7.02
90-99	5.35	5.48	5.80	6.32	6.58	6.76	6.62	6.25	5.84	5.43	5.22	5.14	5.90
1900-09	5.64	5.74	6.01	6.74	7.02	7.11	7.15	6.92	6.47	6.09	5.75	5.63	6.35
10-19	5.58	5.67	5.87	6.57	6.92	7.18	7.11	6.80	6.45	6.08	5.88	5.70	6.32
20-29	5.30	5.28	5.54	6.14	6.49	6.58	6.53	6.28	5.90	5.60	5.42	5.45	5.88
30-39	4.43	4.63	4.92	5.51	5.72	5.75	5.62	5.39	4.96	4.55	4.29	4.12	4.99
Mean	5.72	5.80	6.06	6.65	6.99	7.14	7.08	6.79	6.38	6.01	5.77	5.69	6.34
Minimum monthly means	3.15 (1935)	2.99 (1936)	3.56 (1935)	3.87 (1935)	4.16 (1935)	4.39 (1935)	4.26 (1934)	3.77 (1934)	3.44 (1934)	3.20 (1934)	2.93 (1934)	2.96 (1934)	
Maximum monthly means	7.92 (1886)	7.99 (1870-86)	8.13 (1886)	8.84 (1870)	9.66 (1870)	9.32 (1870)	9.32 (1862)	8.96 (1862)	8.25 (1862)	8.36 (1861)	8.43 (1861)	8.21 (1861)	
Minimum yearly mean 1935	3.15	3.30	3.56	3.87	4.16	4.39	4.56	4.28	3.86	3.52	3.41	3.31	3.78
Maximum yearly mean 1870	7.79	7.99	7.94	8.84	9.66	9.32	8.99	8.60	7.91	7.57	7.07	6.78	8.21

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO

ASSUMING OUTLET CONDITIONS AS AT PRESENT AND A CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860	247.20	247.24	247.34	247.38	247.62	248.10	248.48	247.89	247.43	247.24	247.33	247.34	
1	7.07	7.08	7.57	7.72	8.71	9.16	8.92	8.71	8.18	8.36	8.43	8.21	
2	7.75	7.29	7.66	8.54	9.54	9.26	9.32	8.96	8.25	7.29	7.35	7.19	
3	7.31	7.40	7.47	8.12	8.70	8.82	8.43	7.89	7.56	7.31	7.15	7.17	
4	6.90	6.77	6.84	7.35	8.35	8.81	8.50	8.00	7.50	7.17	7.16	7.26	
5	7.63	7.82	7.97	8.06	8.25	8.26	8.18	7.61	6.98	6.71	6.44	6.30	
6	6.09	6.11	6.07	6.54	6.72	7.40	7.41	7.33	7.24	7.17	6.86	6.82	
7	6.60	6.43	7.07	8.06	8.70	9.13	8.76	8.15	7.60	7.03	6.29	5.56	
8	5.11	5.20	5.45	6.13	6.58	7.17	7.05	6.76	6.61	6.08	5.78	5.97	
9	5.89	5.99	6.14	6.68	7.33	7.57	7.90	7.97	7.75	7.69	7.32	7.45	
Mean	6.76	6.73	6.96	7.46	8.05	8.37	8.30	7.93	7.51	7.21	7.01	6.93	7.43
1870	247.79	247.99	247.94	248.84	249.66	249.32	248.39	248.60	247.91	247.57	247.07	246.78	
1	6.67	6.50	6.69	7.26	7.72	7.65	7.50	7.06	6.72	6.24	5.84	5.55	
2	5.39	5.19	5.04	5.52	5.66	5.85	6.00	5.85	5.50	5.39	5.29	5.04	
3	4.96	5.06	5.18	7.00	7.55	7.50	7.46	7.17	6.75	6.34	6.24	6.40	
4	6.96	7.33	7.89	7.80	7.76	7.88	7.82	7.56	6.94	6.54	6.03	5.68	
5	5.39	5.07	5.32	6.04	6.31	6.48	6.54	6.36	6.17	5.90	5.74	5.55	
6	5.92	6.58	7.11	8.10	8.69	8.92	8.99	8.53	7.90	7.56	7.20	7.00	
7	6.52	6.25	6.39	7.06	7.13	7.02	7.05	6.80	6.38	6.00	5.88	6.01	
8	6.10	6.19	6.98	7.23	7.57	7.55	7.51	7.47	7.18	6.93	6.81	7.59	
9	7.39	7.06	6.93	7.29	7.40	7.40	7.26	6.91	6.52	6.09	5.74	5.75	
Mean	6.31	6.32	6.55	7.21	7.55	7.56	7.51	7.23	6.80	6.46	6.18	6.14	6.82

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO

ASSUMING OUTLET CONDITIONS AS AT PRESENT AND A CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	245.93	246.25	246.56	246.75	246.93	247.13	247.12	246.69	246.35	245.99	245.94	245.75	
1	5.39	5.38	6.02	6.41	6.60	6.80	6.90	6.59	6.02	5.83	5.83	5.84	
2	6.34	6.52	7.12	7.40	7.61	8.15	8.13	7.79	7.40	6.90	6.48	6.24	
3	5.93	5.98	6.22	6.75	7.38	8.09	8.65	8.45	7.97	7.53	7.28	7.16	
4	7.11	7.50	8.18	8.78	8.82	8.71	8.61	8.24	7.82	7.13	6.64	6.49	
5	6.49	6.23	5.95	6.61	7.39	7.76	7.90	7.76	7.52	7.34	7.39	7.56	
6	7.92	7.99	8.13	8.78	9.01	8.76	8.37	7.91	7.56	7.16	6.84	6.78	
7	6.50	7.24	7.75	7.96	8.54	8.50	8.21	7.70	7.27	6.86	6.50	6.22	
8	5.91	5.76	6.00	6.66	6.80	6.77	6.83	6.73	6.32	5.95	5.87	5.87	
9	6.08	6.24	6.40	6.65	6.81	7.14	7.34	7.07	6.55	6.03	5.64	6.19	
Mean	6.36	6.51	6.83	7.28	7.59	7.78	7.81	7.49	7.08	6.67	6.44	6.41	7.02
1890	246.71	247.06	247.45	247.67	248.05	248.75	248.56	247.84	247.45	247.10	247.18	246.97	
1	6.63	6.90	7.48	7.99	7.75	7.31	7.01	6.55	6.10	5.45	4.86	4.85	
2	4.93	4.90	5.03	5.61	5.67	6.24	6.78	6.69	6.48	6.02	5.74	5.61	
3	5.28	5.19	5.67	6.42	7.63	7.88	7.59	7.03	6.76	6.17	5.79	5.65	
4	5.98	6.18	6.49	6.54	6.72	7.27	7.06	6.47	5.93	5.68	5.36	4.99	
5	4.92	4.86	4.76	5.28	5.41	5.30	5.01	4.78	4.43	4.12	3.87	3.89	
6	4.24	4.70	4.91	5.83	5.85	5.76	5.49	5.35	4.88	4.66	4.41	4.43	
7	4.31	4.27	4.73	5.37	5.83	6.04	6.03	6.02	5.51	4.89	4.83	4.89	
8	5.06	5.49	5.90	6.35	6.51	6.57	6.28	5.93	5.50	5.25	5.29	5.31	
9	5.39	5.29	5.55	6.11	6.37	6.51	6.35	5.88	5.37	4.95	4.85	4.78	
Mean	5.35	5.48	5.80	6.32	6.58	6.76	6.62	6.25	5.84	5.43	5.22	5.14	5.90

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO

ASSUMING OUTLET CONDITIONS AS AT PRESENT AND A CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	245.00	245.39	245.63	246.37	246.58	246.50	246.42	246.14	245.65	245.32	245.18	245.46	
1	5.34	5.29	5.08	6.27	6.51	6.61	6.40	6.08	5.75	5.32	4.94	4.99	
2	5.13	5.08	5.86	6.20	6.18	6.22	6.68	6.85	6.33	6.00	5.70	5.57	
3	5.54	5.67	6.49	7.39	7.28	7.17	7.26	7.01	6.68	6.31	5.56	5.18	
4	4.82	5.10	5.74	7.10	7.70	7.91	7.96	7.71	7.30	6.91	6.42	5.90	
5	5.89	5.60	5.40	6.20	6.29	6.64	7.02	6.95	6.80	6.51	6.08	5.91	
6	6.19	6.17	5.97	6.32	6.43	6.47	6.62	6.28	5.83	5.62	5.69	5.79	
7	6.44	6.58	6.56	6.95	7.18	7.23	7.24	7.05	6.57	6.45	6.39	6.42	
8	6.77	7.05	7.57	8.24	8.67	8.83	8.52	8.12	7.30	6.50	6.08	5.67	
9	5.32	5.42	5.84	6.35	7.34	7.48	7.35	7.01	6.45	5.99	5.49	5.36	
Mean	5.64	5.74	6.01	6.74	7.02	7.11	7.15	6.92	6.47	6.09	5.75	5.63	6.35
1910	245.12	245.19	245.94	246.16	246.61	246.66	246.47	246.22	245.87	245.57	245.33	245.05	
1	4.91	5.00	5.09	5.63	5.75	5.85	5.76	5.40	5.10	4.85	4.72	4.82	
2	4.91	5.01	5.24	6.50	6.97	7.52	7.22	6.89	6.61	6.39	6.29	6.29	
3	6.69	6.92	6.87	8.04	8.20	8.28	8.10	7.61	7.04	6.56	6.30	6.13	
4	5.80	6.07	5.85	6.95	7.19	7.16	6.95	6.58	6.38	5.85	5.47	5.05	
5	4.91	5.2[illegible]	5.47	5.22	5.37	5.35	5.36	5.69	5.69	5.39	5.18	5.02	
6	5.28	5.63	5.68	6.61	7.36	8.12	8.25	7.65	6.94	6.30	5.91	5.62	
7	5.50	5.31	5.39	6.47	6.75	7.28	7.80	7.68	7.25	6.97	6.97	6.91	
8	6.29	6.24	6.87	7.44	7.42	7.32	7.18	6.75	6.47	6.27	6.27	6.17	
9	6.35	6.15	6.28	6.71	7.60	8.24	8.02	7.59	7.11	6.62	6.38	5.97	
Mean	5.58	5.67	5.87	6.57	6.92	7.18	7.11	6.80	6.45	6.08	5.88	5.70	6.32

TABLE No.2 Cont
4

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO AT OSWEGO

ASSUMING OUTLET CONDITIONS AS AT PRESENT AND A CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	245.56	245.25	245.31	245.80	245.83	245.80	245.95	245.88	245.76	245.57	245.49	245.65	
1	5.77	5.69	6.02	6.62	6.91	6.85	6.65	6.20	5.70	5.39	5.14	5.11	
2	4.97	4.94	5.35	6.30	6.82	7.03	7.19	6.85	6.32	5.89	5.43	4.89	
3	4.74	4.70	4.98	5.57	5.87	6.19	6.06	5.69	5.30	4.92	4.60	4.73	
4	4.99	5.11	5.21	5.60	6.43	6.65	6.55	6.41	5.98	5.76	5.22	4.83	
5	4.44	4.65	5.45	5.88	5.92	5.70	5.49	5.16	4.83	4.57	4.52	4.76	
6	4.48	4.32	4.38	5.20	5.64	5.60	5.48	5.28	5.09	5.10	5.52	5.69	
7	5.54	5.54	6.00	6.20	6.13	6.28	6.24	6.06	5.61	5.32	5.20	5.87	
8	6.30	6.32	6.31	6.77	6.95	6.94	7.08	6.99	6.57	6.10	6.03	6.15	
9	6.19	6.28	6.40	7.46	8.40	8.80	8.65	8.31	7.84	7.37	7.05	6.79	
Mean	5.30	5.28	5.54	6.14	6.49	6.58	6.53	6.28	5.90	5.60	5.42	5.45	5.88
1930	246.87	247.28	247.94	248.31	248.32	248.37	248.34	247.82	247.13	246.45	245.85	245.50	
1	5.18	4.97	4.89	5.19	5.37	5.69	5.50	5.18	4.87	4.52	4.26	4.17	
2	4.59	5.26	5.46	6.05	5.39	5.29	5.12	5.86	5.32	4.85	4.63	4.54	
3	4.52	4.49	4.49	5.10	5.54	5.71	5.45	5.04	4.62	4.07	3.68	3.61	
4	3.79	3.87	3.87	4.51	4.74	4.52	4.26	3.77	3.44	3.20	2.93	2.96	
5	3.15	3.30	3.56	3.87	4.16	4.39	4.56	4.28	3.86	3.52	3.41	3.31	
6	3.18	2.99	3.64	5.19	5.47	5.23	4.96	4.42	4.19	3.95	3.92	3.57	
7	4.12	4.77	4.95	5.16	5.95	6.21	6.23	5.97	5.52	5.02	5.02	4.85	
8	4.62	4.95	5.48	6.02	6.10	6.03	5.87	5.84	5.44	5.14	4.83	4.54	
9	4.32	4.37	4.91	5.74	6.15	6.06	5.94	5.71	5.19	4.81	4.39	4.15	
Mean	4.43	4.63	4.92	5.51	5.72	5.75	5.62	5.39	4.96	4.55	4.29	4.12	4.99

F.H.102.21

LAKE ONTARIO

ACTUAL MONTHLY MEAN OUTFLOWS

From Fyle H.99

General Engineering Branch,
Department of Transport,
Ottawa, May, 1940.

F.H.102.22

LAKE ONTARIO

AVERAGE MONTHLY MEAN, MINIMUM AND MAXIMUM ACTUAL OUTFLOWS IN 1,000 C.F.S.

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	229	219	229	269	284	288	286	279	269	262	262	260	261
70-79	220	216	225	261	270	272	272	265	256	249	243	239	249
80-89	218	220	227	263	270	275	275	268	[illegible]	[illegible]	[illegible]	246	252
90-99	206	199	209	244	251	255	253	244	236	227	223	221	231
1900-09	205	203	212	248	255	258	259	254	246	239	231	228	237
10-19	207	199	207	242	251	256	255	249	241	235	231	227	233
20-29	198	192	201	234	242	243	243	237	229	223	220	220	224
30-39	184	183	191	222	228	229	225	218	210	203	198	194	207
Mean	208	204	213	248	256	260	259	252	243	236	232	229	237
Minimum monthly means	158 (1935)	144 (1936)	167 (1935)	186 (1935)	193 (1935)	198 (1935)	194 (1934)	186 (1934)	180 (1934)	175 (1934)	170 (1934)	170 (1934)	
Maximum monthly means	256 (1870)	255 (1870)	255 (1874)	299 (1870)	314 (1862) (1870)	308 (1870)	[illegible] (1862) (1870)	297 (1861)	285 (1861)	286 (1861)	288 (1861)	290 (1861)	
Minimum yearly mean 1934	159	162	172	202	205	201	194	186	180	175	170	170	181
Maximum yearly mean 1861	240	240	248	282	301	306	303	297	285	286	288	290	281

General Engineering Branch,
Dept. of Transport,
June, 1940.

ACTUAL MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO - IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860						279	283	278	271	262	273	265	
1	240	240	248	282	301	306	303	297	285	286	288	290	
2	252	240	238	291	314	305	305	294	284	274	265	264	
3	245	242	242	279	296	297	290	280	272	263	260	259	
4	217	219	238	266	288	297	289	282	269	262	273	268	
5	234	221	238	282	282	285	281	269	257	248	245	243	
6	214	199	215	246	257	268	270	267	261	259	262	271	
7	231	222	233	279	295	303	294	281	268	253	247	230	
8	211	185	207	244	250	264	260	255	251	242	239	242	
9	215	200	198	256	271	277	283	284	276	272	268	269	
Mean	229	219	229	269	284	288	286	279	269	262	262	260	261
1870	256	255	249	299	314	308	305	294	279	274	264	256	
1	228	223	239	266	274	274	271	263	254	247	235	231	
2	198	183	187	221	233	239	241	236	232	225	227	209	
3	191	191	199	251	268	272	270	264	258	248	244	246	
4	236	232	255	273	270	278	279	272	260	252	243	235	
5	203	176	195	236	247	250	252	248	242	236	231	226	
6	216	225	225	283	295	301	302	290	276	274	262	252	
7	208	224	227	259	263	262	262	256	247	236	235	237	
8	221	218	234	263	271	271	269	269	266	258	255	272	
9	239	234	235	263	269	269	265	256	250	241	230	229	
Mean	220	216	225	261	270	272	272	265	256	249	243	239	249

ACTUAL MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO - IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	219	224	230	254	259	263	261	252	245	237	241	227	
1	182	192	213	244	248	253	256	248	240	253	251	234	
2	225	228	241	265	267	282	282	274	263	255	243	244	
3	191	195	212	250	264	279	289	284	276	266	262	259	
4	228	231	245	291	295	293	288	283	272	262	252	249	
5	216	233	206	243	268	276	279	273	270	265	264	271	
6	253	249	254	294	297	296	288	280	272	265	262	259	
7	232	238	248	285	291	291	285	273	262	257	244	240	
8	212	194	207	250	254	256	255	254	247	238	238	237	
9	225	212	218	254	256	264	267	261	250	236	234	243	
Mean	218	220	227	263	270	275	275	268	260	251	247	246	252
1890	237	240	249	273	280	289	292	276	270	261	262	255	
1	227	229	244	278	274	265	263	253	243	228	221	220	
2	201	186	190	230	233	246	259	254	252	240	233	231	
3	201	183	199	247	271	278	274	260	257	245	236	231	
4	217	196	228	250	254	267	262	248	238	232	228	219	
5	196	179	185	223	229	226	220	216	208	201	195	195	
6	187	188	186	232	236	235	230	227	216	209	209	205	
7	187	181	192	228	238	243	240	240	227	215	211	216	
8	199	208	211	242	249	250	244	236	227	221	221	223	
9	203	197	209	240	246	249	244	234	224	215	213	215	
Mean	206	199	209	244	251	255	253	244	236	227	223	221	231

ACTUAL MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO IN 1,000 C.F.S.

	1	2	3	4	5	6	7	8	9	10	11	12	
YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	196	198	203	240	246	247	246	238	231	222	218	226	
1	202	198	193	235	245	249	243	237	230	224	213	216	
2	200	181	210	237	239	242	248	250	243	237	230	225	
3	208	207	223	256	259	255	258	254	250	239	228	222	
4	192	195	208	255	267	274	275	271	262	255	243	226	
5	196	206	200	239	242	250	258	257	254	248	241	238	
6	228	220	218	242	244	247	250	242	235	231	229	230	
7	210	216	221	254	260	261	262	257	249	247	245	244	
8	218	215	228	277	288	290	285	277	261	247	238	229	
9	202	195	211	241	261	265	262	255	244	236	224	222	
Mean	205	203	212	248	255	258	259	254	246	239	231	228	237
1910	196	187	214	237	247	248	246	242	231	226	220	215	
1	192	187	194	224	230	231	230	223	213	211	212	211	
2	189	179	185	235	252	266	256	251	243	242	241	243	
3	228	226	234	270	273	277	276	263	251	242	240	237	
4	221	200	200	245	253	253	250	243	239	229	224	215	
5	196	190	190	220	220	218	220	226	226	223	216	212	
6	202	202	200	244	260	274	275	265	251	240	230	223	
7	202	202	204	241	245	256	267	264	255	253	249	245	
8	217	199	226	257	260	258	256	247	242	236	238	234	
9	223	217	223	250	266	276	272	265	254	244	239	233	
Mean	207	199	207	242	251	256	255	249	241	235	231	227	233

TABLE No.3 C

ACTUAL MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO - IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	200	191	195	229	229	229	233	229	227	225	219	225	
1	213	208	219	245	250	250	245	237	227	220	210	214	
2	196	185	199	241	247	251	259	248	238	228	228	207	
3	190	185	185	221	229	236	231	227	218	208	204	207	
4	198	194	195	224	240	242	243	239	230	230	218	208	
5	171	176	201	227	230	226	221	216	208	203	206	209	
6	183	169	175	213	225	223	222	217	214	217	225	224	
7	197	186	205	235	237	242	238	233	224	216	214	230	
8	220	214	216	246	249	249	252	249	241	233	230	234	
9	215	213	222	261	282	284	282	276	265	254	250	238	
Mean	198	192	201	234	242	243	243	237	229	223	220	220	224
1930	232	233	250	275	277	278	276	264	253	240	230	221	
1	200	191	192	216	220	224	220	212	207	201	196	193	
2	190	204	204	232	238	235	233	227	215	207	203	203	
3	191	185	184	211	221	224	217	208	202	193	184	179	
4	159	162	172	202	205	201	194	186	180	175	170	170	
5	158	159	167	186	193	198	201	197	188	182	176	174	
6	159	144	168	218	222	218	210	199	194	193	191	185	
7	186	194	197	215	232	237	236	230	222	214	214	210	
8	184	189	193	233	235	233	229	228	220	215	211	205	
9	185	172	184	230	240	237	233	228	218	212	202	197	
Mean	184	183	191	222	228	229	225	218	210	203	198	194	207

F.H.102.22

ACTUAL MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO - IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT	NOV.	DEC.	MEAN
1940	176	173	174										
1													
2													
3													
4													
5													
6													
7													
8													
9													
Mean													
1950													
1													
2													
3													
4													
5													
6													
7													
8													
9													
Mean													

LAKE ONTARIO

MONTHLY MEAN OUTFLOWS

Assuming continuous diversion of 3,200 c.f.s. at Chicago.

Note:

Actual outflows from fyle H.99 (F.H. 102.22)

Actual diversions at Chicago - F. H. 102.11

General Engineering Branch,
Dept. of Transport,
June, 1940.

F.H. 102.23

LAKE ONTARIO

AVERAGE MONTHLY MEAN, MINIMUM AND MAXIMUM OUTFLOWS IN 1,000 C.F.S.

Assuming Continuous Diversion of 3,200 c.f.s. at Chicago

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	226	215	225	266	281	285	283	275	266	259	259	257	258
70-79	216	213	221	258	267	269	268	262	253	246	240	236	246
80-89	214	216	224	260	267	272	272	265	257	248	244	243	249
90-99	202	196	206	241	248	252	250	241	233	224	220	218	228
1900-09	207	205	213	248	257	260	260	256	247	240	232	230	238
10-19	210	203	211	247	255	261	260	254	246	240	236	232	238
20-29	203	197	207	239	247	249	248	243	235	229	227	225	229
30-39	188	187	195	226	232	233	229	223	214	207	202	197	211
Mean	208	204	213	248	257	260	259	252	244	237	233	230	237
Minimum monthly mean	163 (1934)	148 (1936)	172 (1935) (1936)	191 (1935)	198 (1935)	203 (1935)	200 (1934)	192 (1934)	185 (1934)	180 (1934)	175 (1934)	175 (1934)	
Maximum monthly mean	253 (1870)	252 (1870)	252 (1874)	295 (1870)	311 (1862) (1870)	305 (1870)	302 (1870)	293 (1861)	281 (1861)	283 (1861)	285 (1861)	287 (1861)	
Minimum yearly mean 1934	163	166	176	207	210	206	200	192	185	180	175	175	186
Maximum yearly mean 1861	237	237	245	279	297	303	300	293	281	283	285	287	277

General Engineering Branch,
Dept. of Transport
June, 1940.

TABLE No.4 Cont'd

1.

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING CONTINUOUS DIVERSION OF 3,200 C. F. S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860						276	280	275	267	259	269	262	
61	237	237	245	279	297	303	300	293	281	283	285	287	
62	249	236	234	288	311	302	301	291	281	271	262	261	
63	242	239	238	276	293	294	287	277	269	260	257	255	
64	214	216	235	263	285	294	286	278	266	259	269	265	
65	231	217	235	279	279	282	278	265	254	245	241	240	
66	211	196	211	243	254	265	267	263	257	256	259	268	
67	227	218	229	276	292	300	291	277	265	249	244	227	
68	207	182	204	241	247	261	257	252	248	239	236	239	
69	212	197	195	252	268	274	280	281	273	269	264	266	
Mean	226	215	225	266	281	285	283	275	266	259	259	257	258
1870	253	252	246	295	311	305	302	291	275	271	261	253	
71	224	220	235	263	271	271	268	260	251	244	232	227	
72	195	180	184	218	229	236	238	235	229	22[illegible]	224	206	
73	188	188	196	248	265	269	267	260	254	244	240	243	
74	233	229	252	270	266	274	275	269	257	248	240	232	
75	199	173	192	233	244	247	249	245	239	233	228	223	
76	212	221	222	280	292	297	298	286	273	271	259	249	
77	204	220	224	256	259	259	259	253	263	233	232	234	
78	217	215	231	260	268	267	266	266	263	255	252	269	
79	236	230	232	260	265	266	261	253	247	238	227	225	
Mean	216	213	221	258	267	269	268	262	253	246	240	236	246

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	206	220	226	251	263	259	258	248	242	234	238	224	
81	179	189	210	241	245	250	253	245	237	229	228	231	
82	222	224	238	261	264	279	279	271	259	252	239	240	
83	188	191	208	247	261	276	286	281	272	263	259	255	
84	225	228	242	288	292	290	285	279	269	259	249	246	
85	213	230	203	240	265	273	275	270	267	262	261	268	
86	250	246	251	291	294	293	284	277	269	262	259	255	
87	229	234	245	282	288	288	282	269	259	253	241	237	
88	209	191	204	247	251	253	252	251	244	235	234	234	
89	222	209	215	251	253	261	264	258	247	233	231	240	
Mean	214	216	224	260	267	272	272	265	257	248	244	243	249
1890	233	237	246	270	277	286	289	273	267	258	259	252	
91	224	226	240	275	271	261	260	249	240	225	218	217	
92	198	183	187	227	230	243	256	251	249	237	230	228	
93	198	179	196	243	268	275	271	256	253	242	233	228	
94	214	193	225	247	251	264	259	245	235	229	225	216	
95	193	176	182	220	225	223	216	213	205	198	132	192	
96	184	185	183	229	233	232	227	224	212	206	206	201	
97	184	178	189	225	234	240	237	237	224	212	208	212	
98	196	205	208	239	245	246	241	233	224	218	218	220	
99	200	194	206	236	242	246	241	231	221	212	209	212	
Mean	202	196	206	241	248	252	250	241	233	224	220	218	228

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	195	197	202	240	246	247	246	238	230	223	219	227	
01	204	200	195	236	244	248	243	238	231	225	214	217	
02	201	182	211	238	240	243	250	251	244	238	231	228	
03	211	209	225	257	260	257	260	256	251	240	229	224	
04	194	197	210	257	269	275	276	272	263	256	244	227	
05	198	208	202	240	243	251	259	258	255	249	241	239	
06	229	221	219	243	246	249	250	243	235	233	231	232	
07	212	218	223	256	261	263	265	260	250	248	246	246	
08	219	216	231	271	292	294	289	280	265	250	241	232	
09	205	198	214	244	264	269	266	259	247	239	227	225	
Mean	207	205	213	248	257	260	260	256	247	240	232	230	238
1910	200	191	218	241	251	252	249	246	234	229	223	219	
11	194	190	196	228	233	235	235	227	218	216	216	215	
12	192	182	188	239	255	270	261	255	248	247	245	247	
13	231	230	237	274	277	282	281	269	257	247	245	241	
14	217	205	203	249	258	258	255	248	245	234	229	220	
15	200	194	194	223	225	223	225	232	231	228	221	217	
16	207	207	204	248	265	279	281	270	256	244	235	228	
17	207	207	209	246	250	262	274	271	262	258	255	250	
18	222	205	231	263	265	264	262	253	247	242	243	240	
19	228	222	228	256	272	282	278	270	259	250	245	238	
Mean	210	203	211	247	255	261	260	254	246	240	236	232	238

F.H.102.23

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING CONTINUOUS DIVERSION OF 3,200 C.F.S. AT CHICAGO.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	205	196	201	234	234	234	238	235	233	230	225	230	
21	218	213	224	250	255	255	250	242	232	225	216	219	
22	201	190	204	245	253	257	264	254	243	234	234	212	
23	195	189	190	226	234	241	237	232	223	214	209	212	
24	203	199	202	231	246	250	249	247	236	236	223	213	
25	176	181	206	233	235	232	227	221	213	208	210	213	
26	187	173	180	218	230	229	227	222	218	221	231	230	
27	202	190	211	239	241	245	243	239	231	223	221	234	
28	225	221	222	253	256	256	259	256	248	240	238	241	
29	222	220	228	265	285	291	288	282	273	262	258	245	
Mean	203	197	207	239	247	249	248	243	235	229	227	225	229
1930	237	238	255	282	282	283	281	271	259	245	234	225	
31	204	196	196	221	225	230	225	218	212	206	202	198	
32	195	208	208	236	243	240	238	232	221	213	208	208	
33	195	188	189	216	226	230	222	213	207	197	189	184	
34	163	166	176	207	210	206	200	192	185	180	175	175	
35	164	164	172	191	198	203	206	201	192	187	182	179	
36	162	148	172	221	226	221	214	203	199	195	195	186	
37	189	197	199	218	235	241	240	235	226	218	218	214	
38	187	193	198	238	238	237	233	232	224	217	214	207	
39	185	172	184	230	240	237	233	228	218	212	202	197	
Mean	188	187	195	226	232	233	229	223	214	207	202	197	211

TABLE No.5

LAKE ONTARIO

AVERAGE MONTHLY MEAN, MINIMUM AND MAXIMUM ACTUAL TOTAL NET SUPPLIES IN 1,000 C.F.S.

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	220	227	260	316	320	298	269	248	240	242	250	252	262
70-79	220	225	261	301	284	271	258	236	225	224	229	235	247
80-89	224	238	258	293	290	284	264	239	227	227	236	246	252
90-99	213	216	242	275	268	256	233	214	203	202	211	219	229
1900-09	210	217	251	286	270	263	251	227	214	211	213	223	236
10-19	208	211	242	284	273	262	240	223	212	213	217	217	233
20-29	195	201	236	273	259	243	230	211	202	205	215	223	224
30-39	195	202	225	257	242	235	206	187	179	177	181	189	206
MEAN	211	217	247	286	276	263	244	223	213	213	219	226	236
Minimum monthly means	148 (1936)	162 (1936)	189 (1935)	209 (1935)	204 (1934)	180 (1934)	164 (1934)	153 (1934)	155 (1935)	155 (1933-34)	160 (1934)	170 (1935)	
Maximum monthly means	278 (1870)	289 (1887)	298 (1867)	364 (1870)	356 (1861)	328 (1883)	302 (1883)	279 (1869)	271 (1861)	296 (1861)	283 (1861)	296 (1878)	
Minimum yearly mean 1934	171	166	195	234	204	180	164	153	158	155	160	178	177
Maximum yearly mean 1861	229	260	273	327	356	314	286	268	271	296	283	264	286

General Engineering Branch,
Dept. of Transport,
June 1940.

LAKE ONTARIO

MONTHLY MEAN SUPPLIES

assuming:-

1. - 3,200 c.f.s. diverted at Chicago
2. - 5,000 c.f.s. added from Ogoki and Long Lac.

Note

Supplies obtained as follows:-

(a) Storage in Lake obtained from water levels of Lake at first and last of each month, based on average monthly mean levels at Oswego as obtained from U.S.L.S. Detroit, Feb. 7, 1940.

(b) Storage added to outflows corrected for 3,200 c.f.s. diverted at Chicago and 5,000 c.f.s. added from Ogoki and Long Lac.

General Engineering Branch,
Dept. of Transport,
Ottawa, May, 1940.

F.H. 102.27

TABLE No. 6 Cont'd
1

TOTAL MONTHLY MEAN SUPPLY TO LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING 3,200 C.F.S. DIVERTED TO CHICAGO AND 5,000 C.F.S. ADDED FROM OGOKI AND LONG LAC

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860						313	277	238	247	260	278	256	
1	231	262	275	329	358	316	288	270	273	298	285	266	
2	218	237	289	364	344	299	295	255	221	240	263	264	
3	255	251	272	329	325	289	256	248	251	248	256	250	
4	202	219	264	328	346	305	260	244	238	251	278	289	
5	259	235	250	295	292	283	257	222	223	227	230	230	
6	207	200	234	275	295	297	269	262	255	245	249	263	
7	216	245	300	345	338	308	257	238	225	202	187	182	
8	197	201	249	293	294	286	245	239	225	209	237	249	
1869	217	212	229	306	309	301	301	281	266	257	260	289	
Mean	222	229	262	318	322	300	271	250	242	244	252	254	264
1870	280	263	284	366	334	284	280	253	240	243	234	241	
1	218	226	272	309	291	268	248	234	223	213	208	212	
2	185	170	204	248	248	257	243	218	214	217	213	187	
3	195	202	282	352	290	271	258	237	225	229	247	278	
4	276	270	276	269	275	282	268	239	220	216	210	210	
5	178	175	238	279	268	262	249	234	224	220	218	235	
6	261	276	288	346	329	314	288	249	241	249	241	226	
7	179	220	263	291	263	260	256	230	216	217	238	248	
8	234	256	274	289	286	270	268	258	246	245	284	298	
1879	219	216	247	284	275	265	246	227	218	210	217	239	
Mean	222	227	263	303	286	273	260	238	227	226	231	237	249

P.H. 102.27

TOTAL MONTHLY MEAN SUPPLY TO LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING 3,200 C.F.S. DIVERTED TO CHICAGO AND 5,000 C.F.S. ADDED FROM OGOKI AND LONG LAC

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	242	251	252	271	276	272	245	222	218	221	232	206	
1	170	220	258	270	266	267	249	213	211	226	234	257	
2	255	261	279	286	299	305	270	247	228	219	217	223	
3	182	208	245	299	319	330	304	259	241	241	249	253	
4	244	275	297	317	294	287	271	254	240	227	228	245	
5	207	212	224	304	316	299	280	260	255	261	275	294	
6	271	259	286	329	298	273	257	251	243	238	248	247	
7	253	291	278	318	314	280	256	230	223	229	221	220	
8	195	200	243	283	260	259	256	236	219	223	236	248	
1889	240	227	236	272	275	286	267	234	212	202	242	286	
Mean	226	240	260	295	292	286	266	241	229	229	238	248	254
1890	272	270	274	297	322	310	260	237	244	253	259	236	
1	226	263	286	290	250	239	236	219	202	180	199	224	
2	205	191	221	258	259	291	278	245	228	213	219	215	
3	186	200	249	324	328	279	243	230	226	209	217	240	
4	239	218	244	261	284	283	233	207	209	212	202	203	
5	193	174	204	252	232	211	200	194	183	180	187	212	
6	222	218	234	271	234	223	216	204	189	192	201	202	
7	182	200	239	274	266	253	242	221	183	189	213	227	
8	225	244	247	267	259	243	221	207	202	215	225	229	
1899	204	205	243	273	263	250	222	197	188	196	207	220	
Mean	215	218	244	277	270	258	235	216	205	204	213	221	231

TOTAL MONTHLY MEAN SUPPLY TO LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING 3,200 C.F.S. DIVERTED TO CHICAGO AND 5,000 C.F.S. ADDED FROM OGOKI AND LONG LAC

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	218	226	246	280	256	245	236	215	202	206	228	237	
1	200	194	240	302	265	248	227	216	206	196	205	230	
2	209	217	260	256	246	267	279	243	215	218	217	223	
3	220	253	299	293	256	260	260	239	229	224	211	198	
4	196	239	295	341	310	292	272	252	238	225	207	210	
5	190	193	233	283	266	285	277	254	242	227	223	247	
6	242	217	231	266	257	263	249	217	210	230	244	266	
7	248	229	244	285	277	270	261	241	235	245	249	267	
8	251	248	277	320	321	295	267	237	210	207	208	207	
1909	201	225	255	308	314	274	252	228	213	206	208	214	
Mean	217	224	258	293	277	270	258	234	220	218	220	230	243
1910	198	228	260	272	276	251	238	227	213	212	209	208	
11	198	203	224	258	247	238	220	205	200	205	221	231	
12	208	200	252	313	301	282	239	235	233	240	248	269	
13	262	243	286	329	290	281	258	230	222	225	235	228	
14	220	213	244	306	269	254	237	229	220	206	203	202	
15	213	222	200	224	232	227	243	249	226	212	211	226	
16	237	228	249	319	329	315	266	226	209	208	213	217	
17	200	208	261	304	285	305	293	255	240	254	258	230	
18	200	231	284	289	264	258	244	232	235	239	243	248	
1919	234	224	254	311	338	306	258	239	226	224	225	211	
Mean	217	220	251	293	283	272	250	233	222	223	227	227	243

TOTAL MONTHLY MEAN SUPPLY TO LAKE ONTARIO IN 1,000 C.F.S.

ASSUMING 3,200 C.F.S. DIVERTED TO CHICAGO AND 5,000 C.F.S. ADDED FROM OGOKI AND LONG LAC

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	181	191	227	261	240	243	245	230	226	226	234	248	
1	225	227	266	291	269	247	228	209	205	207	210	220	
2	201	209	264	309	286	276	262	223	211	204	200	192	
3	193	204	229	266	263	253	221	207	198	191	207	234	
4	223	209	227	285	287	260	245	229	218	213	193	189	
5	174	225	259	256	233	219	211	201	195	203	225	216	
6	175	173	217	272	251	227	221	214	221	242	255	236	
7	203	212	242	254	251	252	234	214	205	211	253	287	
8	244	224	244	283	268	265	266	239	217	226	243	253	
1929	232	237	286	354	337	300	275	250	237	235	243	250	
Mean	205	211	246	283	269	254	241	222	213	216	226	233	235
1930	266	283	298	303	291	289	260	227	215	202	202	202	
1	187	190	210	244	248	240	208	196	191	188	195	217	
2	245	249	245	277	257	236	224	203	186	191	202	211	
3	200	191	215	262	255	229	200	186	176	165	175	195	
4	180	175	204	244	214	191	175	164	169	165	171	188	
5	182	186	199	219	225	225	208	180	166	171	179	180	
6	156	171	265	297	234	207	185	176	188	191	186	200	
7	240	237	218	263	282	255	233	212	194	202	216	205	
8	196	230	245	270	246	231	230	219	204	200	196	197	
1939	188	200	244	285	257	234	223	204	187	185	180	184	
Mean	204	211	234	266	251	234	215	197	188	186	190	198	215

TABLE SHOWING GREATEST MINIMUM FLOW POSSIBLE WITH LAKE ONTARIO

REGULATED BETWEEN ELEVATIONS 249.00 AND 244.50

Note: - Assuming continuous diversion of 3,200 c.f.s. at Chicago and addition of 5 000 c.f.s. from Ogoki and Long Lac.

Date		Supply 1,000 c.f.s.	Flow 1,000 c.f.s.	Storage 1,000 c.f.s.	Storage ft.	W.L. Lake Ontario at end of month
1933	July					249.00
	Aug.	186	198	- 12	- 0.15	48.85
	Sept.	176	198	- 22	- 0.27	48.58
	Oct.	165	198	- 33	- 0.41	48.17
	Nov.	175	198	- 23	- 0.29	47.88
	Dec.	195	198	- 3	- 0.04	47.84
1934	Jan.	180	198	- 18	- 0.23	47.61
	Feb.	175	198	- 23	- 0.29	47.32
	Mar.	204	198	+ 6	+ 0.08	47.40
	Apr.	244	198	+ 46	+ 0.57	47.97
	May	214	198	+ 16	+ 0.20	48.17
	June	191	198	- 7	- 0.09	48.08
	July	175	198	- 23	- 0.29	47.79
	Aug.	164	198	- 34	- 0.42	47.37
	Sept	169	198	- 29	- 0.36	47.01
	Oct.	165	198	- 33	- 0.41	46.60
	Nov.	171	198	- 27	- 0.34	46.26
	Dec.	188	198	- 10	- 0.12	46.14
1935	Jan.	182	198	- 16	- 0.20	45.94
	Feb.	186	198	- 12	- 0.15	45.79
	Mar.	199	198	+ 1	+ 0.01	45.80
	Apr.	219	198	+ 21	+ 0.26	46.06
	May	225	198	+ 27	+ 0.34	46.40
	June	225	198	+ 27	+ 0.34	46.74
	July	208	198	+ 10	+ 0.12	46.86
	Aug.	180	198	- 18	- 0.22	46.64
	Sept.	166	198	- 32	- 0.40	46.24
	Oct.	171	198	- 27	- 0.34	45.90
	Nov.	179	198	- 19	- 0.24	45.66
	Dec.	180	198	- 18	- 0.22	45.44
1936	Jan.	156	198	- 42	- 0.53	44.91
	Feb.	171	198	- 27	- 0.34	244.57
	Mar.	265	198	+ 67	+ 0.84	45.41
	Apr.	297	198	+ 99	+ 1.24	46.65

REGULATION OF LAKE ONTARIO

METHOD NO. 5

MONTHLY MEAN OUTFLOWS
1860 - 1939

Regulation based on 5,000 c.f.s.
added from Ogoki and Long Lac and
continuous diversion of 3,200
c.f.s. at Chicago

General Engineering Branch,
Dept. of Transport,
Ottawa, August, 1940.

TABLE No.
Cont d

REGULATION OF LAKE ONTARIO (METHOD NO. 5)

AVERAGE MONTHLY MEAN, MINIMUM AND MAXIMUM OUTFLOWS IN 1,000 C. F. S.

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860 - 69	215	223	233	264	273	296	299	285	287	275	275	233	264
70 - 79	211	220	230	259	266	277	275	270	270	254	250	218	250
80 - 89	211	221	234	260	264	287	287	273	273	257	253	221	254
90 - 99	207	214	219	236	239	258	259	249	244	230	228	206	232
1900 - 09	209	217	224	250	256	270	271	263	262	246	240	212	243
10 - 19	209	217	222	246	254	273	272	260	259	245	244	215	243
20 - 29	209	215	219	237	242	257	257	252	248	235	233	211	235
30 - 39	200	203	208	218	222	237	236	230	223	210	206	195	216
Mean	209	216	224	246	252	269	270	260	258	244	241	214	242
Minimum monthly mean	188 (1935)	185 (1936)	187 (1936)	187 (1935)	187 (1935)	193 (1935)	194 (1934)	193 (1934)	187 (1934)	183 (1934)	180 (1934)	185 (1934)	
Maximum monthly mean	221	234	257	298	310	310	310	310	310	310	310	268	
Minimum yearly mean 1934	195	192	191	190	193	195	194	193	187	183	180	185	190
Maximum yearly mean 1861	213	226	247	286	289	310	310	310	310	310	310	268	282

F.H. 102.34

TABLE No.8
Cont'd

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO UNDER REGULATION (METHOD NO. 5) IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860						272	295	282	278	272	300	246	
61	213	226	247	286	289	310	310	310	310	310	310	268	282
62	221	231	249	294	303	310	310	310	310	280	273	240	278
63	216	231	251	291	293	310	310	277	285	280	285	232	272
64	212	221	223	260	277	310	310	280	282	265	287	249	265
65	219	234	251	281	280	297	283	267	257	245	243	216	256
66	210	219	213	226	235	273	287	274	290	287	280	229	252
67	213	224	239	286	293	310	310	294	286	256	234	203	262
68	220	200	200	214	232	273	281	260	261	248	235	216	237
69	213	223	226	242	258	294	294	295	310	310	302	234	267
Mean	215	223	233	264	273	296	299	285	287	275	275	233	264
1870	216	234	256	298	310	310	310	310	310	287	279	218	278
71	211	222	230	266	274	288	273	259	257	245	236	208	247
72	206	206	200	199	200	216	241	244	239	231	230	205	218
73	204	206	205	246	278	291	276	265	264	249	246	229	247
74	217	235	258	296	284	292	282	273	272	248	239	210	259
75	205	204	199	207	219	248	258	254	253	243	238	211	228
76	210	227	250	295	300	310	310	310	310	287	286	221	277
77	209	210	212	242	253	257	261	259	254	241	235	216	237
78	213	226	246	277	277	288	274	270	281	273	278	254	263
79	219	229	244	266	262	269	267	256	252	240	232	209	245
Mean	211	220	230	259	266	277	275	270	270	254	250	218	250

TABLE No. 8
Cont'd

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO UNDER REGULATION (METHOD NO. 5) IN 1,000 C. F. S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	209	224	242	262	253	267	270	257	250	239	237	212	244
81	208	206	209	229	233	254	263	256	244	234	236	214	232
82	214	230	251	287	283	308	301	279	284	256	243	213	262
83	207	207	208	225	246	297	310 ×	304	302	280	276	229	258
84	212	226	249	294	293	310	295	279	288	269	251	218	265
85	211	221	218	232	251	298	293	283	295	288	305	244	262
86	217	234	255	298	301	310 ×	301	272	282	271	267	230	270
87	212	227	253	295	294	310 ×	304	273	267	248	246	215	262
88	208	212	210	225	239	250	258	258	257	242	239	216	235
89	214	227	242	254	248	265	278	271	265	242	230	217	246
Mean	211	221	234	260	264	287	287	273	273	257	253	221	254
1890	217	234	257	298	292	310	310 ×	287	283	272	289	234	274
91	211	223	243	279	278	259	251	246	242	227	216	200	240
92	203	207	204	207	209	237	270	271	273	253	239	212	232
93	208	210	208	231	261	310	284	260	258	247	236	211	244
94	209	223	227	243	235	268	277	252	241	230	228	203	236
95	204	205	200	198	201	210	215	217	212	202	198	193	205
96	200	205	208	218	224	233	231	230	226	212	212	196	216
97	201	200	200	208	217	246	253	249	244	221	216	201	221
98	206	215	225	244	239	251	248	238	232	222	228	206	230
99	209	217	213	231	235	252	253	240	230	215	216	199	226
Mean	207	214	219	236	239	258	259	249	244	230	228	206	232

F.H. 102.34

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO UNDER REGULATION (METHOD NO. 5) IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	204	211	215	235	243	249	249	246	240	225	224	206	229
01	210	217	211	230	249	257	254	242	239	227	221	202	230
02	206	212	214	236	230	242	258	268	268	245	239	211	236
03	209	220	234	276	277	264	264	262	261	249	243	210	247
04	206	208	215	268	283	310	294	279	286	260	249	212	257
05	205	207	204	211	226	251	272	272	281	269	251	217	239
06	212	226	234	244	238	250	261	255	245	234	238	217	238
07	217	231	247	270	268	273	271	265	266	256	271	231	254
08	215	229	249	287	289	310	310	281	278	244	234	207	261
09	204	207	212	238	258	298	278	263	257	240	231	207	241
Mean	209	217	224	250	256	270	271	263	262	246	240	212	243
1910	205	208	212	237	240	262	256	249	248	235	230	205	232
11	206	209	207	211	213	235	240	234	229	218	220	203	219
12	209	217	212	239	260	289	281	257	259	250	258	232	247
13	216	232	250	294	295	310	292	271	266	247	244	218	261
14	210	221	221	246	261	264	260	249	249	239	229	204	238
15	204	210	212	207	201	213	223	238	251	241	232	207	220
16	210	223	231	257	274	310	309	280	268	241	233	209	254
17	206	210	209	236	254	275	291	289	294	274	293	231	255
18	210	216	221	264	255	261	261	253	253	249	251	228	244
19	214	227	240	266	275	310	310	275	275	253	245	214	259
Mean	209	217	222	246	254	273	272	260	259	245	244	215	243

TABLE No. 8
Cont'd
4

MONTHLY MEAN OUTFLOWS FROM LAKE ONTARIO UNDER REGULATION (METHOD NO. 5) IN 1,000 C.F.S.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	208	208	204	209	213	229	240	246	247	240	238	215	225
21	214	226	240	268	268	267	256	244	236	226	224	203	239
22	206	210	210	240	260	276	275	267	255	239	230	204	239
23	202	202	202	208	213	243	251	238	232	220	216	200	219
24	206	216	214	226	240	271	264	255	252	240	233	203	235
25	201	198	203	217	218	230	228	226	222	212	216	201	214
26	207	206	200	203	210	230	231	231	231	229	240	221	220
27	215	224	227	242	230	244	252	244	239	227	226	215	232
28	219	232	248	272	270	268	267	266	264	244	243	223	251
29	214	226	243	284	294	310	310×	304	298	273	264	227	271
Mean	209	215	219	237	242	257	257	252	248	235	233	211	235
1930	212	230	254	298	295	310×	300	274	265	244	232	205	260
31	203	202	200	200	200	217	233	225	221	209	208	194	209
32	203	215	228	247	248	252	245	238	230	215	214	198	228
33	202	204	202	204	208	233	233	224	216	201	190	189	209
34	195	192	191	190	193	195	194	193	187	183	180	185	190
35	188	186	189	187	187	193	199	207	202	189	183	188	191
36	192	185	187	197	211	220	217	214	204	198	198	192	201
37	198	207	213	218	220	260	259	247	239	222	221	203	226
38	204	207	212	228	233	241	239	239	237	225	221	199	224
39	202	202	202	212	227	246	242	237	230	214	211	193	218
Mean	200	203	208	218	222	237	236	230	223	210	206	195	216

F.H.102 34

TABLE No.9

REGULATION OF LAKE ONTARIO

METHOD NO. 5

MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO

1860 - 1939

Regulation based on 5,000 c.f.s. added from Ogoki and Long Lac and continuous diversion of 3,200 c.f.s. at Chicago

General Engineering Branch,
Dept. of Transport.
Ottawa, August, 1940.

F.H.102.33

TABLE No. 9 Cont'd

REGULATION OF LAKE ONTARIO (METHOD NO. 5)

AVERAGE MONTHLY MEAN, MINIMUM AND MAXIMUM LAKE LEVELS

PERIOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860-69	246.36	246.46	246.68	247.23	247.84	248.09	247.93	247.53	247.03	246.56	246.22	246.15	247.01
70-79	6.19	6.31	6.46	7.07	7.44	7.55	7.43	7.14	6.67	6.23	5.93	5.91	6.69
80-89	6.21	6.43	6.71	7.12	7.48	7.64	7.50	7.16	6.68	6.22	5.95	6.01	6.76
90-99	5.74	5.82	6.00	6.45	6.84	7.07	6.92	6.56	6.11	5.71	5.45	5.45	6.18
1900-09	5.93	6.03	6.29	6.80	7.18	7.31	7.22	6.96	6.51	6.08	5.78	5.77	6.49
10-19	5.93	5.99	6.20	6.70	7.15	7.33	7.18	6.87	6.47	6.11	5.86	5.81	6.47
20-29	5.89	5.85	5.99	6.46	6.90	7.06	6.94	6.64	6.24	5.91	5.74	5.83	6.29
30-39	5.06	5.13	5.35	5.84	6.30	6.47	6.30	5.97	5.55	5.17	4.92	4.85	5.58
Mean	5.91	6.00	6.21	6.71	7.14	7.32	7.18	6.85	6.41	6.00	5.73	5.72	6.43
Minimum monthly mean	4.07 (1936)	3.77 (1936)	4.00 (1935)	4.28 (1935)	4.72 (1935)	5.16 (1935)	5.02 (1934)	4.72 (1934)	4.43 (1934)	4.20 (1934)	4.03 (1934)	4.00 (1934)	
Maximum monthly mean	7.12 (1862)	7.69 (1874)	8.02 (1874)	8.56 (1870)	9.10 (1870)	9.09 (1870)	8.83 (1862)	8.40 (1862)	7.85 (1861)	7.54 (1861)	7.31 (1861)	7.02 (1861)	
Minimum yearly mean 1934	4.40	4.20	4.18	4.60	5.06	5.17	5.02	4.72	4.43	4.20	4.03	4.00	4.50
Maximum yearly mean 1870	7.00	7.58	7.93	8.56	9.10	9.09	8.74	8.20	7.41	6.69	6.14	6.00	7.70

F.H.102.33

MONTHLY MEAN LEVELS OF LAKE ONTARIO UNDER REGULATION (METHOD NO. 5)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1860						247.55	247.70	247.31	246.84	246.57	246.36	246.19	
1	246.45	246.79	247.19	247.67	248.35 4.6	8.81 4.6	8.71 4.4	8.33 3.	7.85	7.54	7.31	7.02	247.67
2	7.12	7.14	7.43	8.17	8.81 4.8	9.00 4.8	8.83 4.6	8.40 3.	7.49	6.69	6.38	6.40	7.66
3	6.86	7.23	7.49	7.90	8.30 4.4	8.37 3.8	7.90	7.38	6.99	6.58	6.20	6.08	7.27
4	6.18	6.11	6.35	7.07	7.89	8.29 3.7	7.95	7.41	6.91	6.56	6.42	6.53	6.97
5	7.12	7.37	7.38	7.48	7.61	7.61	7.35	6.91	6.41	6.09	5.89	5.89	6.93
6	5.97	5.83	5.84	6.30	6.95	7.48	7.51	7.32	7.03	6.54	6.08	6.06	6.58
7	6.33	6.47	6.97	7.76	8.37 4.5	8.64 4.3	8.29 3.7	7.61	6.88	6.16	5.52	5.08	7.01
8	4.94	4.93	5.23	6.06	6.93	7.40	7.25	6.90	6.54	6.07	5.85	6.05	6.18
9	6.29	6.25	6.20	6.65	7.34	7.70	7.80	7.75	7.38	6.78	6.18	6.22	6.88
Mean	6.36	6.46	6.68	7.23	7.84	8.09	7.93	7.53	7.03	6.56	6.22	6.15	247.01
1870	7.00	7.58	7.93	8.56	9.10 5.0	9.09 5.0	8.74 4.4	8.20 3.	7.41	6.69	6.14	6.00	7.70
1	6.19	6.27	6.55	7.10	7.45	7.43	7.15	6.85	6.48	6.07	5.69	5.54	6.56
2	5.44	5.08	4.89	5.22	5.82	6.37	6.65	6.50	6.17	5.93	5.74	5.51	5.78
3	5.36	5.27	5.73	6.93	7.61	7.57	7.33	7.04	6.62	6.25	6.12	6.40	6.52
4	7.10	7.69	8.02	7.99	7.72	7.60	7.45	7.15	6.60	6.08	5.70	5.52	7.05
5	5.36	5.01	5.07	5.78	6.51	6.90	6.93	6.76	6.45	6.13	5.86	5.87	6.05
6	6.35	6.97	6.52	8.13	8.59 4.6	8.80 4.5	8.68 4.3	8.16 3.	7.35	6.68	6.14	5.87	7.35
7	5.73	5.60	5.98	6.63	6.98	7.06	7.05	6.84	6.42	6.03	5.90	6.11	6.36
8	6.45	6.76	7.12	7.39	7.50	7.45	7.29	7.17	6.88	6.48	6.35	6.57	6.95
9	6.95	6.87	6.81	6.95	7.13	7.19	7.03	6.72	6.33	5.94	5.66	5.74	6.61
Mean	6.19	6.31	6.46	7.07	7.44	7.55	7.43	7.14	6.67	6.23	5.93	5.91	246.69

F.H.102.33

MONTHLY MEAN LEVELS OF LAKE ONTARIO UNDER REGULATION (METHOD NO. 5)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1880	246.13	246.51	246.74	246.87	247.07	247.24	247.12	246.74	246.32	246.01	245.87	245.79	246.53
1	5.53	5.38	5.77	6.36	6.79	7.08	7.07	6.71	6.24	5.98	5.92	6.18	6.25
2	6.70	7.15	7.52	7.72	7.79	7.87	7.65	7.26	6.71	6.13	5.74	5.63	6.99
3	5.55	5.41	5.64	6.36	7.24	7.90	8.07	7.75	7.09	6.46	6.05	6.00	6.63
4	6.38	6.88	7.49	7.97	8.07	7.93	7.64	7.34	6.88	6.32	5.90	5.92	7.06
5	6.07	6.00	5.97	6.50	7.31	7.73	7.65	7.43	7.03	6.61	6.26	6.31	6.74
6	7.03	7.52	7.87	8.30	8.44	8.19	7.69	7.28	6.91	6.46	6.13	6.08	7.33
7	6.47	7.13	7.68	8.02	8.25	8.19	7.70	7.13	6.59	6.19	5.92	5.78	7.09
8	5.75	5.60	5.72	6.32	6.79	6.97	7.02	6.86	6.48	6.13	5.99	6.16	6.32
9	6.53	6.70	6.67	6.75	7.02	7.32	7.38	7.08	6.52	5.94	5.76	6.28	6.66
Mean	6.21	6.43	6.71	7.12	7.48	7.64	7.50	7.16	6.68	6.22	5.95	6.01	246.76
1890	7.05	7.62	7.95	8.14	8.24	8.43	8.12	7.48	6.92	6.56	6.25	6.03	7.40
1	6.19	6.53	7.05	7.41	7.29	6.99	6.77	6.50	6.08	5.54	5.14	5.19	6.39
2	5.35	5.26	5.26	5.70	6.02	6.97	7.36	7.25	6.80	6.27	5.90	5.78	6.16
3	5.68	5.49	5.68	6.57	7.52	7.74	7.30	6.85	6.46	6.03	5.67	5.73	6.39
4	6.09	6.24	6.31	6.54	6.94	7.35	7.17	6.61	6.13	5.82	5.55	5.39	6.35
5	5.32	5.06	4.89	5.24	5.78	5.97	5.89	5.65	5.32	5.00	4.79	4.85	5.31
6	5.11	5.33	5.57	6.09	6.47	6.47	6.32	6.06	5.67	5.31	5.12	5.09	5.72
7	5.01	4.89	5.14	5.81	6.51	6.86	6.84	6.60	6.04	5.46	5.25	5.39	5.82
8	5.67	5.97	6.29	6.58	6.83	6.91	6.69	6.33	5.94	5.72	5.65	5.77	6.20
9	5.89	5.79	5.90	6.38	6.80	6.96	6.76	6.29	5.76	5.38	5.21	5.28	6.03
Mean	5.74	5.82	6.00	6.45	6.84	7.07	6.92	6.56	6.11	5.71	5.45	5.45	246.18

MONTHLY MEAN LEVELS OF LAKE ONTARIO UNDER REGULATION (METHOD NO. 5)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1900	245.50	245.68	245.98	246.48	246.81	246.87	246.76	246.48	246.05	245.69	245.60	245.81	246.14
1	5.94	5.74	5.77	6.44	6.95	7.00	6.77	6.44	6.08	5.67	5.38	5.46	6.14
2	5.64	5.69	6.01	6.42	6.64	6.89	7.18	7.16	6.67	6.17	5.86	5.80	6.34
3	5.95	6.22	6.84	7.36	7.33	7.18	7.12	6.96	6.61	6.25	5.90	5.62	6.61
4	5.49	5.61	6.31	7.29	7.88	7.94	7.68	7.37	6.90	6.33	5.80	5.53	6.68
5	5.43	5.25	5.34	5.98	6.66	7.13	7.37	7.29	6.92	6.42	5.99	5.99	6.31
6	6.37	6.51	6.43	6.56	6.81	7.01	7.02	6.70	6.24	6.00	6.01	6.35	6.50
7	6.86	7.04	7.01	7.09	7.23	7.27	7.19	6.98	6.63	6.37	6.16	6.22	6.84
8	6.70	7.05	7.34	7.76	8.13 4.2	8.24	7.87	7.32	6.63	5.97	5.58	5.42	7.00
9	5.40	5.49	5.88	6.62	7.37	7.57	7.26	6.88	6.38	5.90	5.55	5.45	6.31
Mean	5.93	6.03	6.29	6.80	7.18	7.31	7.22	6.96	6.51	6.08	5.78	5.77	246.49
1910	5.46	5.53	5.96	6.50	6.91	7.07	6.89	6.65	6.29	5.92	5.65	5.53	6.20
1	5.50	5.41	5.47	5.88	6.38	6.62	6.52	6.21	5.85	5.59	5.51	5.70	5.89
2	5.87	5.75	5.90	6.65	7.32	7.54	7.23	6.83	6.53	6.31	6.18	6.31	6.54
3	6.86	7.22	7.52	8.00	8.15 4.1	7.94	7.55	7.08	6.54	6.13	5.94	5.94	7.07
4	6.08	6.09	6.18	6.73	7.12	7.11	6.91	6.63	6.33	5.95	5.58	5.39	6.34
5	5.43	5.57	5.57	5.60	5.90	6.17	6.38	6.58	6.50	6.16	5.85	5.83	5.96
6	6.12	6.32	6.46	6.99	7.68	8.06	7.82	7.21	6.50	5.93	5.59	5.51	6.68
7	5.53	5.48	5.78	6.57	7.16	7.54	7.74	7.55	7.01	6.54	6.20	5.92	6.59
8	5.90	5.92	6.42	6.98	7.12	7.09	6.97	6.73	6.49	6.32	6.21	6.25	6.53
9	6.53	6.64	6.71	7.11	7.77	8.14	7.78	7.24	6.70	6.22	5.92	5.76	6.88
Mean	5.93	5.99	6.20	6.70	7.15	7.33	7.18	6.87	6.47	6.11	5.86	5.81	246.47

MONTHLY MEAN LEVELS OF LAKE ONTARIO UNDER REGULATION (METHOD NO. 5)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1920	245.58	245.31	245.34	245.82	246.31	246.57	246.69	246.62	246.39	246.18	246.06	246.24	246.09
1	6.52	6.59	6.76	7.07	7.21	7.09	6.73	6.39	5.98	5.66	5.46	5.48	6.42
2	5.56	5.53	5.85	6.65	7.22	7.38	7.30	6.95	6.39	5.90	5.49	5.22	6.29
3	5.09	5.05	5.23	5.77	6.43	6.80	6.68	6.30	5.89	5.50	5.27	5.43	5.79
4	5.75	5.80	5.84	6.32	6.95	7.18	6.99	6.71	6.34	5.96	5.54	5.20	6.22
5	4.95	4.95	5.47	6.08	6.40	6.43	6.26	6.00	5.67	5.45	5.44	5.59	5.72
6	5.48	5.08	4.97	5.53	6.20	6.44	6.36	6.20	6.02	6.04	6.21	6.40	5.91
7	6.43	6.29	6.30	6.47	6.68	6.86	6.80	6.50	6.10	5.79	5.86	6.48	6.38
8	7.08	7.19	7.12	7.17	7.21	7.18	7.16	6.98	6.51	6.11	5.99	6.16	6.82
9	6.48	6.67	7.01	7.76	8.43 4.6	8.64 4.3	8.35 ×	7.79	7.07	6.46	6.09	6.08	7.24
Mean	5.89	5.85	5.99	6.46	6.90	7.06	6.94	6.64	6.24	5.91	5.74	5.83	246.29
1930	6.60	7.27	7.87	8.22	8.20 4.1	8.04 ×	7.66	7.11	6.51	5.94	5.49	5.27	7.02
1	5.16	4.99	4.98	5.32	5.89	6.33	6.33	5.99	5.62	5.30	5.09	5.15	5.51
2	5.55	6.02	6.34	6.65	6.88	6.84	6.61	6.26	5.77	5.34	5.11	5.13	6.04
3	5.20	5.11	5.11	5.56	6.21	6.48	6.25	5.80	5.32	4.85	4.52	4.47	5.41
4	4.40	4.20	4.18	4.60	5.06	5.17	5.02	4.72	4.43	4.20	4.03	4.00	4.50
5	3.98	3.94	4.00	4.28	4.72	5.16	5.41	5.30	4.91	4.57	4.42	4.35	4.59
6	4.07	3.77	4.17	5.30	6.04	6.11	5.83	5.39	5.05	4.90	4.78	4.76	5.01
7	5.07	5.52	5.74	6.07	6.73	7.09	6.90	6.52	6.02	5.62	5.46	5.44	6.02
8	5.41	5.50	5.85	6.35	6.67	6.69	6.57	6.40	6.07	5.71	5.40	5.22	5.99
9	5.12	5.02	5.28	6.01	6.63	6.74	6.45	6.23	5.75	5.30	4.93	4.67	5.68
Mean	5.06	5.13	5.35	5.84	6.30	6.47	6.30	5.97	5.55	5.17	4.92	4.85	245.58

F.H. 102.33

REGULATION OF LAKE ONTARIO

DATE	IN NATURE		UNDER REGULATION						WITH CORRECTION			
YEAR	DISCHARGE	SUPPLY	DISCHARGE	FROM DIAGRAM STORAGE		W.L. L. ONTARIO END OF PERIOD	CORRECTION TO DISCHARGE IN COLUMN 4	DISCHARGE	STORAGE		W.L. LAKE ONTARIO END OF PERIOD	MEAN
1910	1,000 c.f.s.	1,000 c.f.s.	1,000 c.f.s.	1,000 c.f.s.	feet		1,000 c.f.s.	1,000 c.f.s.	1,000 c.f.s.	feet		
1	2	3	4	5	6	7	8	9	10	12	12	13
Previous Dec.	Aver. Nov - Mar. 222					245.50					245.50	
January	200	198	205	- 7	- 0.09	5.41	0	205			5.41	245.46
February	191	228	208	+20	+ 0.25	5.66	0	208			5.66	5.53
March	218	260	212	+48	+ 0.60	6.26	0	212			6.26	5.96
April 1st	241	272	232	+40	+ 0.25	6.51	-1	231	+ 41	+0.26	6.52	
2nd			245	+27	+ 0.17	6.68	-1	244	+ 28	+0.17	6.69	6.50
May	251	276	242	+34	+ 0.43	7.11	-2	240	+ 36	+0.45	7.14	6.91
June	252	251	263	-12	- 0.15	6.96	-1	262	- 11	-0.14	7.00	7.07
July	249	238	260	-22	- 0.[illegible]8	6.68	-4	256	- [illegible]8	-0.22	6.78	6.89
August	246	227	252	-25	- 0.31	6.37	-3	249	- 22	-0.27	6.51	6.65
September	234	213	247	-34	- 0.42	5.95	+1	248	- 35	-0.44	6.07	6.29
October	229	212	237	-25	- 0.31	5.64	-2	235	- 23	-0.29	5.78	5.92
November	223	209	232	-23	- 0.29	5.35	-2	230	- 21	-0.26	5.52	5.65
December 1st	219	208	207	+ 1	+ 0.01	5.36	0	207		+0.01	5.[illegible]3	
2nd			204	+ 4	+ 0.02	5.38	0	204		+0.02	5.5[illegible]	5.53

Note: Col. 2 = Discharge in nature corrected for diversion of 3,200 c.f.s. at Chicago.

Col. 3 = Net supply corrected for diversion of 3,200 c.f.s. at Chicago and addition of 5,000 c.f.s. from Long Lac and Ogoki.

Water Level, Col. 7, used to determine discharge Col. 4, for following month except for January, when water level in Col. 12 at end of previous December is used.

See next page for explanation of method

TABLE No.10

DESCRIPTION OF METHOD OF DETERMINING MONTHLY DISCHARGES

UNDER REGULATION METHOD NO. 5.

To be read in conjunction with Table No. 10 .

Column 1. Date (year, month, and half month).

" 2. Mean monthly discharge in nature with diversion of 3,200 c.f.s. to Chicago.

" 3 Total monthly mean supply to Lake Ontario including addition of 5,000 c.f.s. from Long Lac and Ogoki and diversion of 3,200 c.f.s. to Chicago.

" 4. Discharge from Rule Curve (Plate No.) using Column 7 for previous month or half month. Note that in entering the Rule Curve the W. L. of Lake Ontario that would have been obtained, had no correction been applied (Col. 7), is used, except for January when the actual W.L. of Lake Ontario at the end of the previous December (Col. 12) is used.

" 5. Col. 3 - Col. 4 = storage for month or half month in c.f.s.

" 6. Col. 5 converted to feet for 1 foot storage equivalent to 80,000 c.f.s. per month.

" 7. Col. 6 added to W. L. of previous month or half month in Col. 7.

" 8. Correction obtained from the Correction Chart (Plate No.) for the total monthly mean supply for the previous month or period shown in Col. 3. (Note: No correction applied in January, February, March or December or in May if positive.)

" 9. Col. 4 + Col. 8.

" 10. Col. 3 - Col. 9.

" 11. Col. 10 converted to feet for 1 foot storage equivalent to 80,000 c.f.s. per month.

" 12. Col. 11 added to W. L. of previous month or half month in Col. 12.

" 13. From Col. 12.

Future Regulation. The procedure of making the calculations for actual regulation in the future will be somewhat different. The order of making the calculations in the Table will be as follows:-

Column 7. For the first period to be regulated the W. L. in this column will be the actual W. L. of Lake Ontario at the end of the previous period.

-2-

Column 4. Discharge from Rule Curve as obtained for W.L. in Col. 7 for end of preceeding period, with exception as noted above for Col. 7.

" 8. Correction obtained from Correction Chart for total monthly mean supply for the previous period shown in Col. 3.

" 9. Col. 4 + Col. 8. This will be the regulated discharge out of Lake Ontario to be maintained during the period by setting the control gates.

" 12. W.L. of Lake Ontario at the end of the period as established by several gauges.

" 11. Difference in W.L. between beginning and end of period as obtained from Col. 12.

" 10. Col. 11 converted to storage in c.f.s. for 1 foot storage equivalent to 80,000 c.f.s. per month.

" 3. Col. 9 + Col. 10 = total monthly mean supply to Lake Ontario for the period.

" 5. Col. 3 - Col. 4 = storage for period in c.f.s.

" 6. Col. 5 converted to feet for 1 foot storage equivalent to 80,000 c.f.s. per month.

" 7. Col. 6 added to W. L. of previous period in Col. 7. This is the W.L. that would have been obtained at the end of the period had no correction been applied.

Starting with Col. 7 the procedure is repeated for each future period.

PLATE No 1

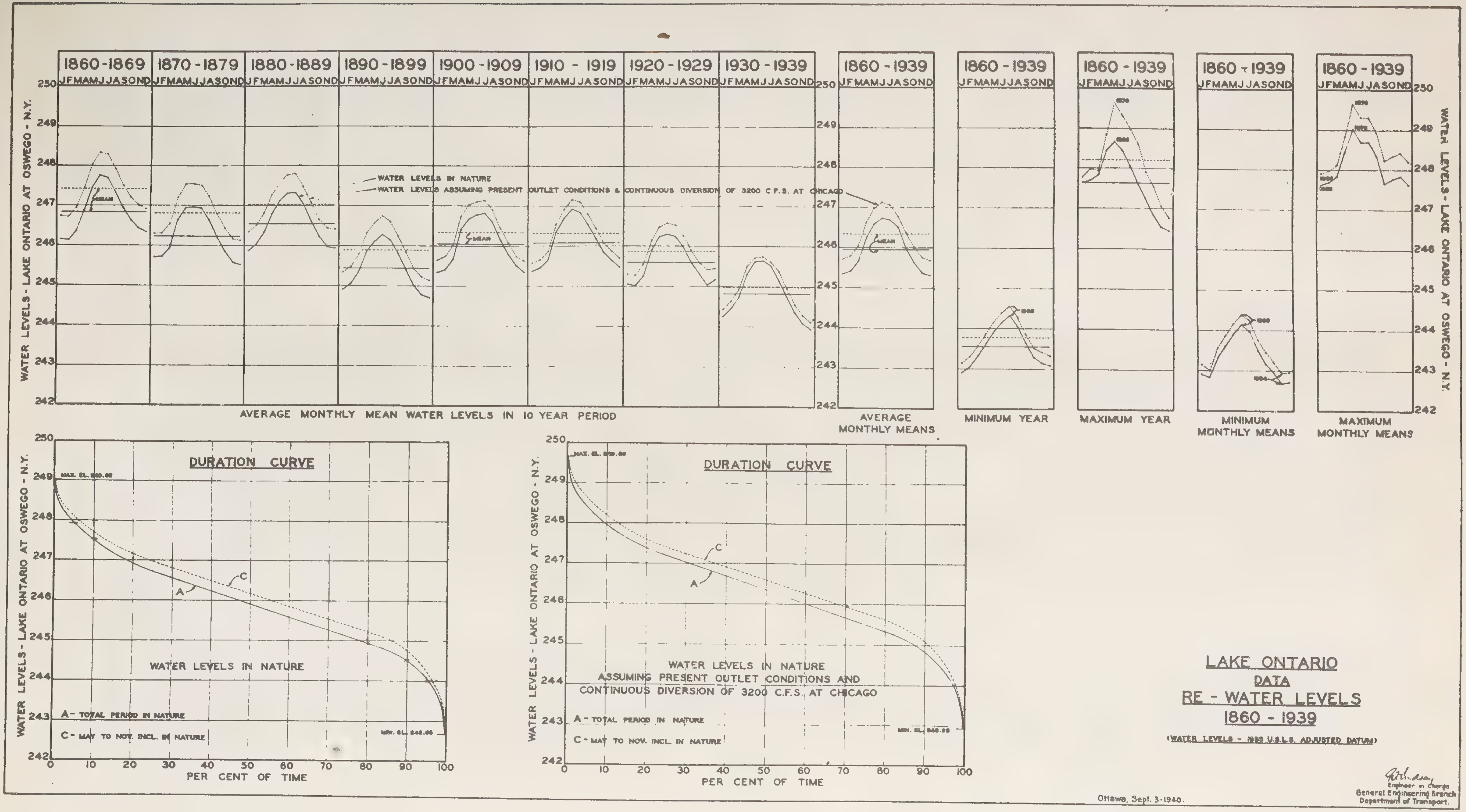
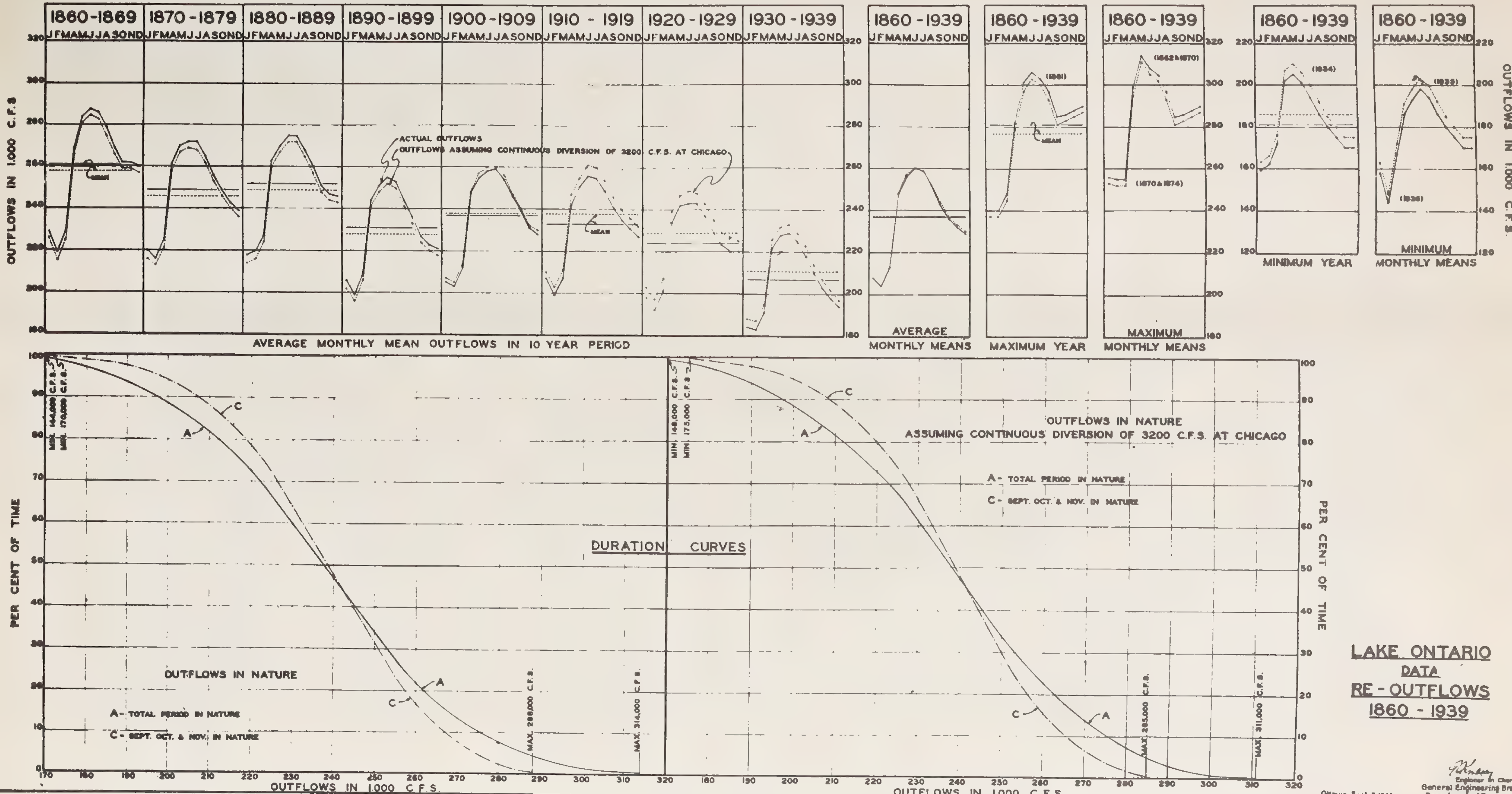

1860-1869
1870-1879
1880-1889
1890-1899
1900-1909
1910 - 1919
1920-1929
1930-1939
JFMAMJJASOND
WATER LEVELS - LAKE ONTARIO AT OSWEGO - N.Y.
WATER LEVELS IN NATURE
WATER LEVELS ASSUMING PRESENT OUTLET CONDITIONS & CONTINUOUS DIVERSION OF 3200 C.F.S. AT CHICAGO
MEAN
AVERAGE MONTHLY MEAN WATER LEVELS IN 10 YEAR PERIOD
1860 - 1939
AVERAGE MONTHLY MEANS
MINIMUM YEAR
MAXIMUM YEAR
MINIMUM MONTHLY MEANS
MAXIMUM MONTHLY MEANS
DURATION CURVE
WATER LEVELS IN NATURE
A - TOTAL PERIOD IN NATURE
C - MAY TO NOV. INCL. IN NATURE
PER CENT OF TIME
DURATION CURVE
WATER LEVELS IN NATURE
ASSUMING PRESENT OUTLET CONDITIONS AND
CONTINUOUS DIVERSION OF 3200 C.F.S. AT CHICAGO
A - TOTAL PERIOD IN NATURE
C - MAY TO NOV. INCL. IN NATURE
PER CENT OF TIME
LAKE ONTARIO
DATA
RE - WATER LEVELS
1860 - 1939
(WATER LEVELS - 1935 U.S.L.S. ADJUSTED DATUM)
Ottawa, Sept. 3-1940.
Engineer in Charge
General Engineering Branch
Department of Transport.

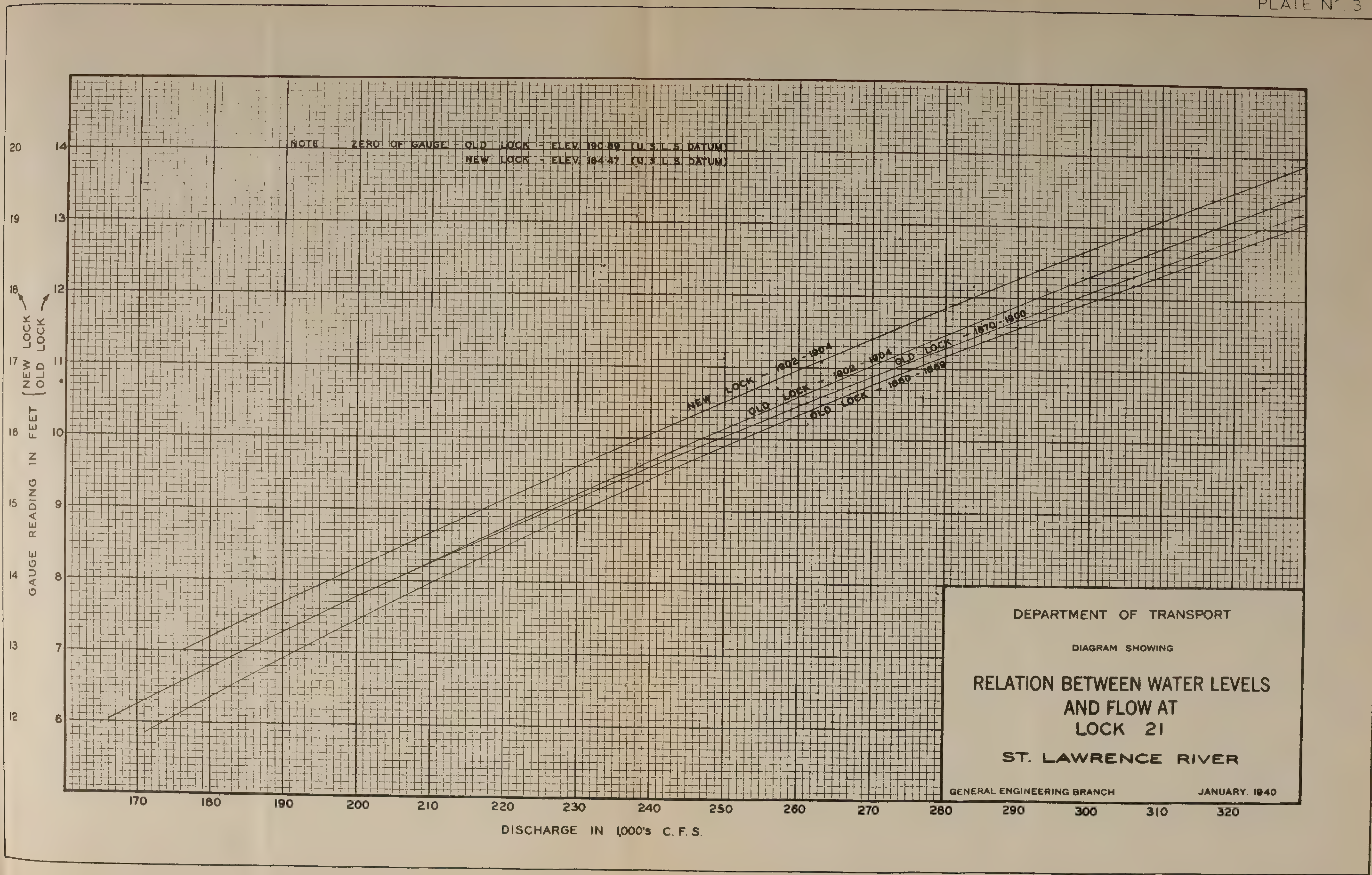
PLATE No. 2

LAKE ONTARIO DATA RE - OUTFLOWS 1860 - 1939

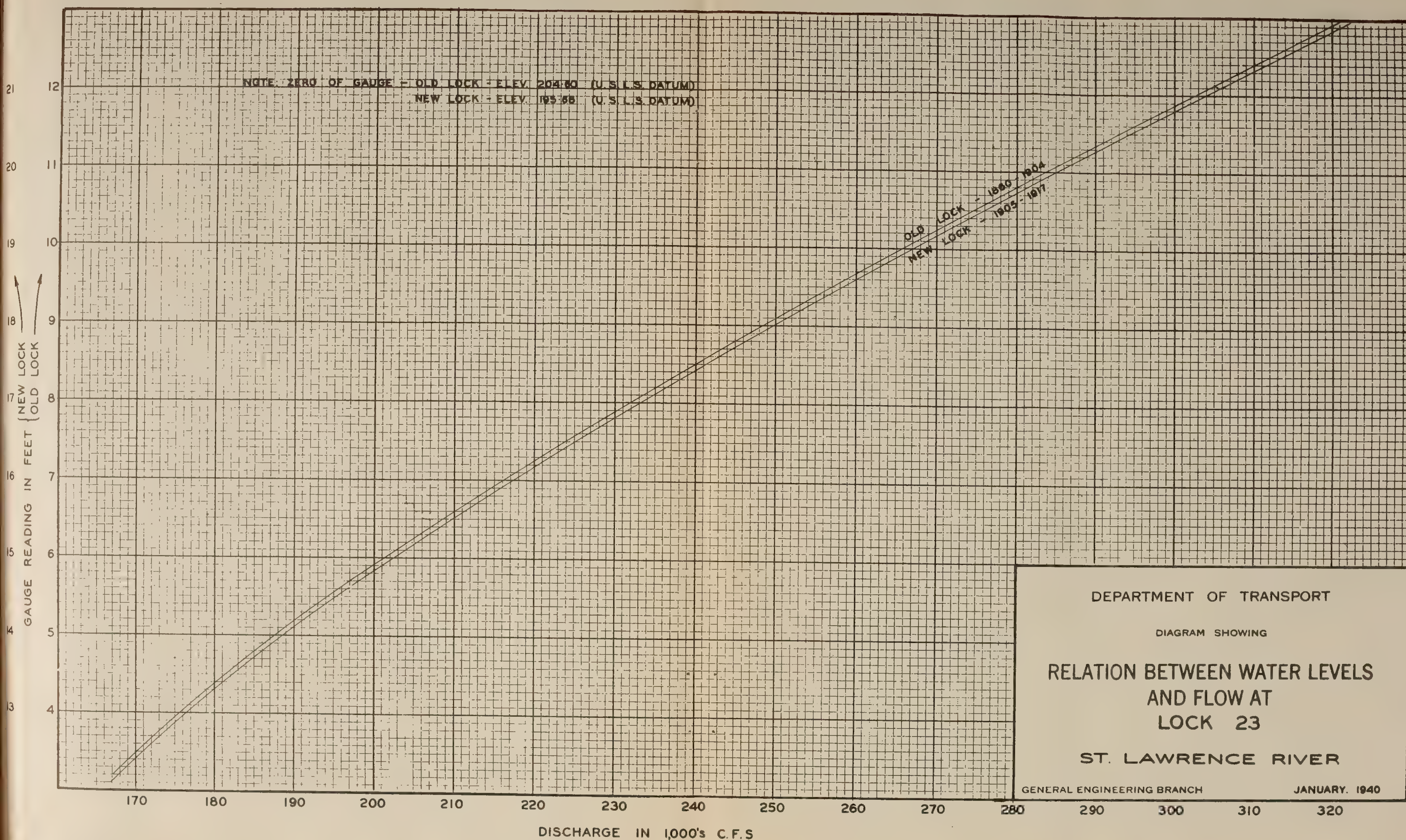


Ottawa, Sept. 3-1940

Engineer in Charge
General Engineering Branch
Department of Transport.



NOTE: ZERO OF GAUGE - OLD LOCK - ELEV. 190.89 (U.S.L.S. DATUM)
NEW LOCK - ELEV. 184.47 (U.S.L.S. DATUM)
NEW LOCK - 1902 - 1904
OLD LOCK - 1902 - 1904
OLD LOCK - 1870 - 1900
OLD LOCK - 1860 - 1869
GAUGE READING IN FEET
NEW LOCK
OLD LOCK
20
19
18
17
16
15
14
13
12
14
13
12
11
10
9
8
7
6
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
DISCHARGE IN 1,000's C.F.S.
DEPARTMENT OF TRANSPORT
DIAGRAM SHOWING
RELATION BETWEEN WATER LEVELS AND FLOW AT LOCK 21
ST. LAWRENCE RIVER
GENERAL ENGINEERING BRANCH
JANUARY. 1940


NOTE: ZERO OF GAUGE - OLD LOCK - ELEV. 204.60 (U.S.L.S. DATUM)
NEW LOCK - ELEV. 195.68 (U.S.L.S. DATUM)
OLD LOCK - 1860 - 1904
NEW LOCK - 1905 - 1917
GAUGE READING IN FEET {NEW LOCK / OLD LOCK}
21 12
20 11
19 10
18 9
17 8
16 7
15 6
14 5
13 4
170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320
DISCHARGE IN 1,000's C.F.S.
DEPARTMENT OF TRANSPORT
DIAGRAM SHOWING
RELATION BETWEEN WATER LEVELS AND FLOW AT LOCK 23
ST. LAWRENCE RIVER
GENERAL ENGINEERING BRANCH
JANUARY. 1940

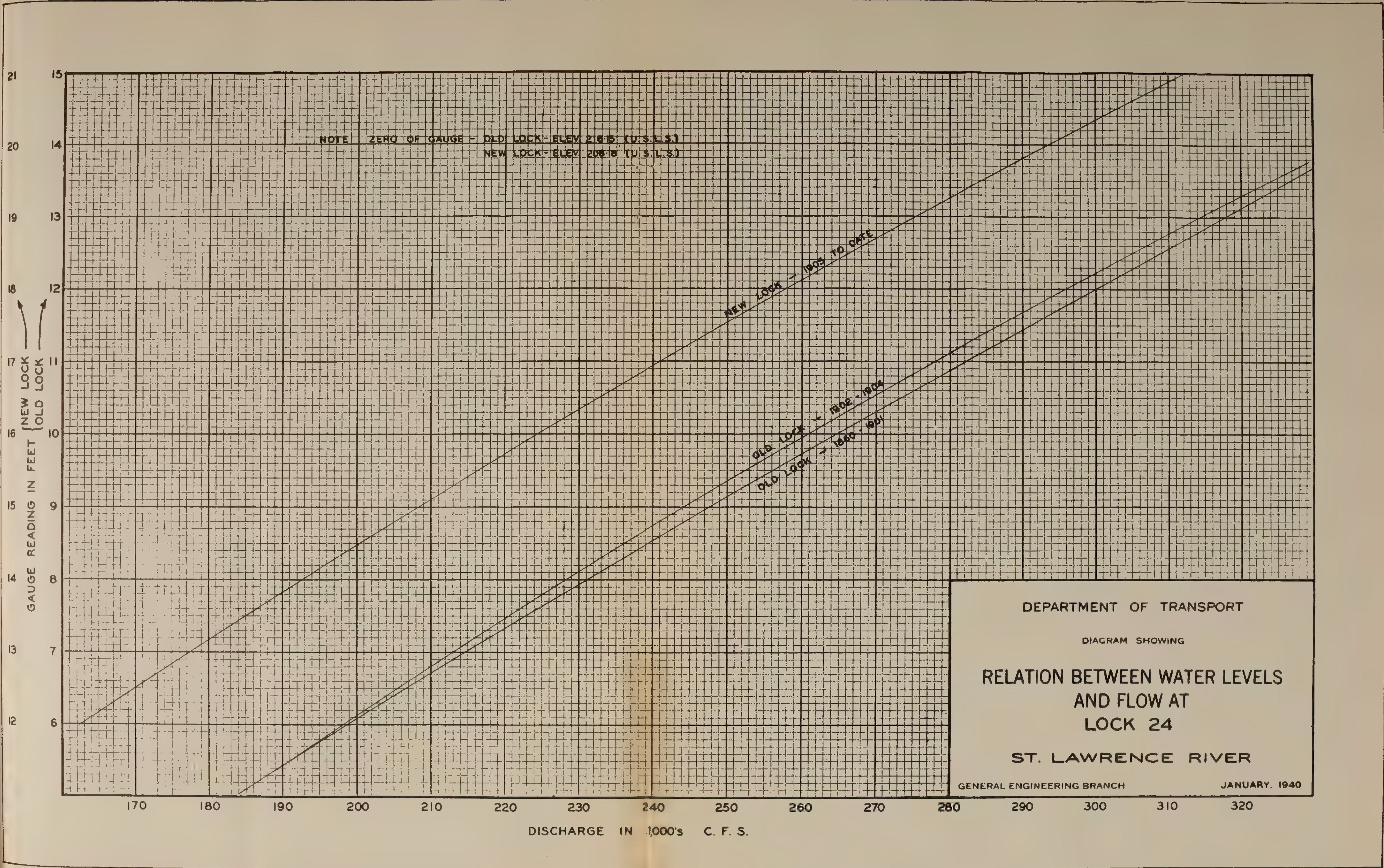
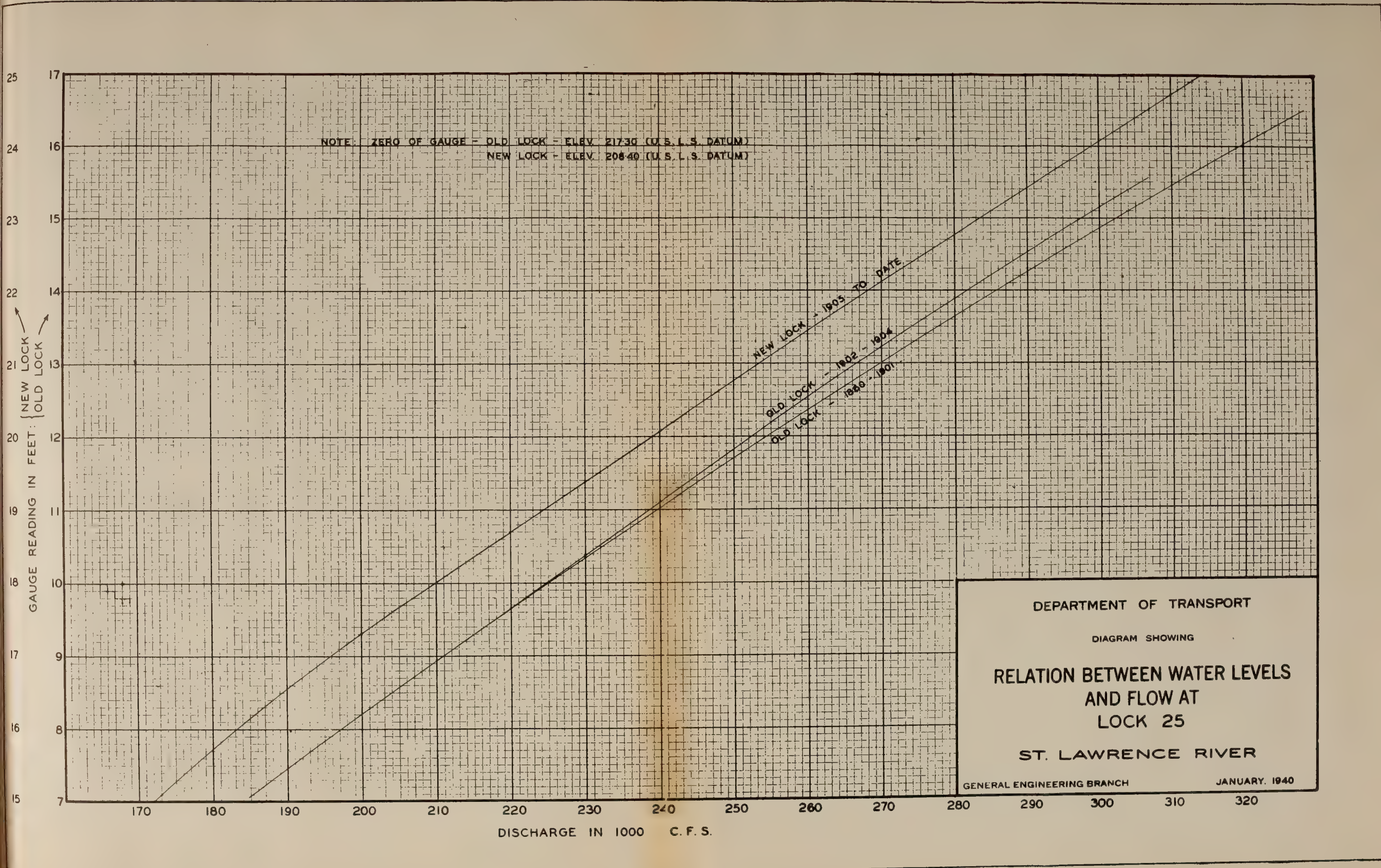
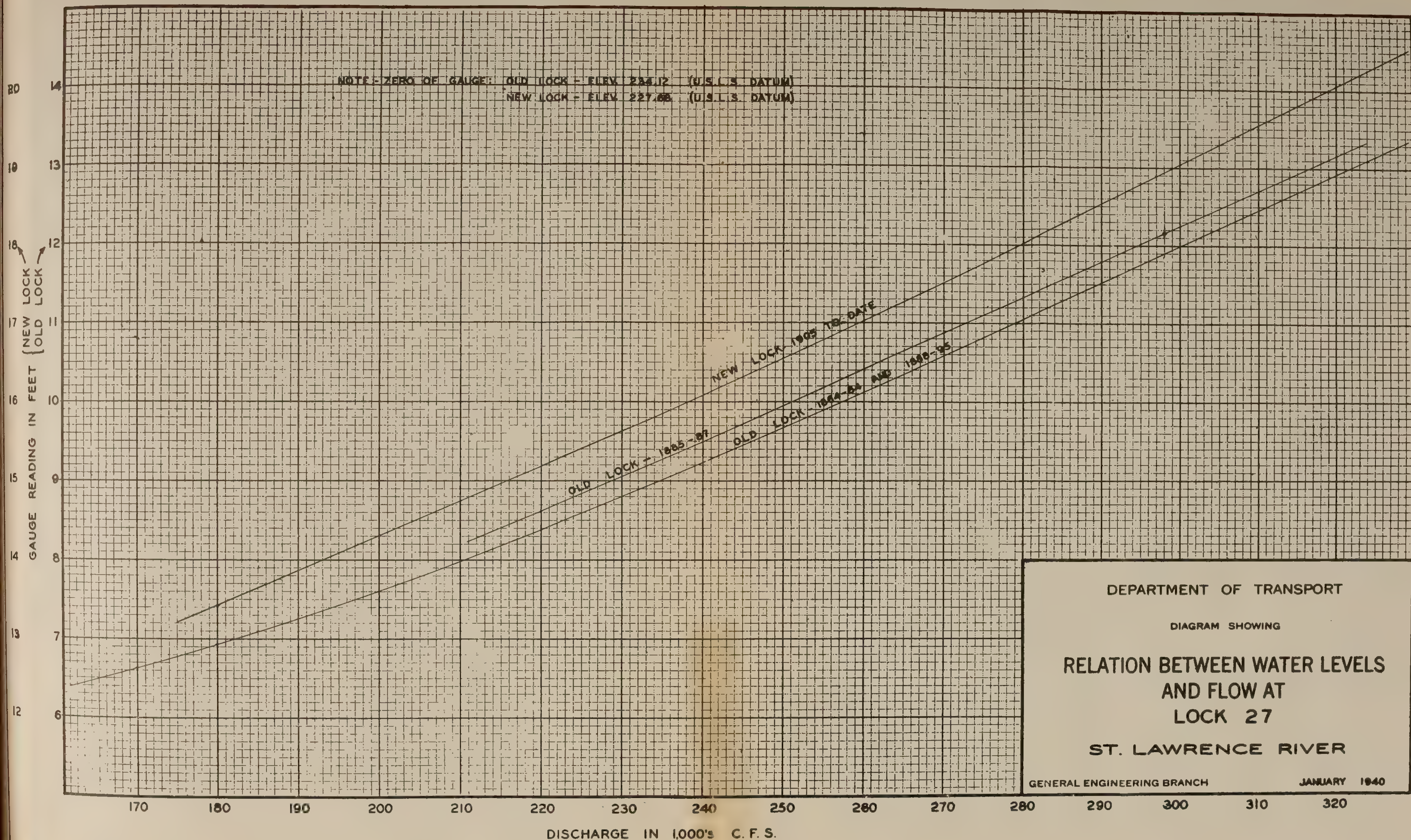

NOTE ZERO OF GAUGE — OLD LOCK - ELEV. 216·15 (U.S.L.S.)
NEW LOCK - ELEV. 208·18 (U.S.L.S.)
NEW LOCK — 1905 TO DATE
OLD LOCK — 1902 - 1904
OLD LOCK — 1860 - 1901
GAUGE READING IN FEET {NEW LOCK / OLD LOCK
21 20 19 18 17 16 15 14 13 12
15 14 13 12 11 10 9 8 7 6
170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320
DISCHARGE IN 1,000's C. F. S.
DEPARTMENT OF TRANSPORT
DIAGRAM SHOWING
RELATION BETWEEN WATER LEVELS AND FLOW AT LOCK 24
ST. LAWRENCE RIVER
GENERAL ENGINEERING BRANCH
JANUARY. 1940

PLATE NO 6


NOTE: ZERO OF GAUGE - OLD LOCK - ELEV. 217.30 (U.S. L.S. DATUM)
NEW LOCK - ELEV. 206.40 (U.S. L.S. DATUM)
NEW LOCK - 1905 TO DATE
OLD LOCK - 1902 - 1904
OLD LOCK - 1880 - 1901
GAUGE READING IN FEET: {NEW LOCK / OLD LOCK}
DISCHARGE IN 1000 C.F.S.
25 24 23 22 21 20 19 18 17 16 15
17 16 15 14 13 12 11 10 9 8 7
170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320
DEPARTMENT OF TRANSPORT
DIAGRAM SHOWING
RELATION BETWEEN WATER LEVELS AND FLOW AT LOCK 25
ST. LAWRENCE RIVER
GENERAL ENGINEERING BRANCH
JANUARY, 1940



DEPARTMENT OF TRANSPORT

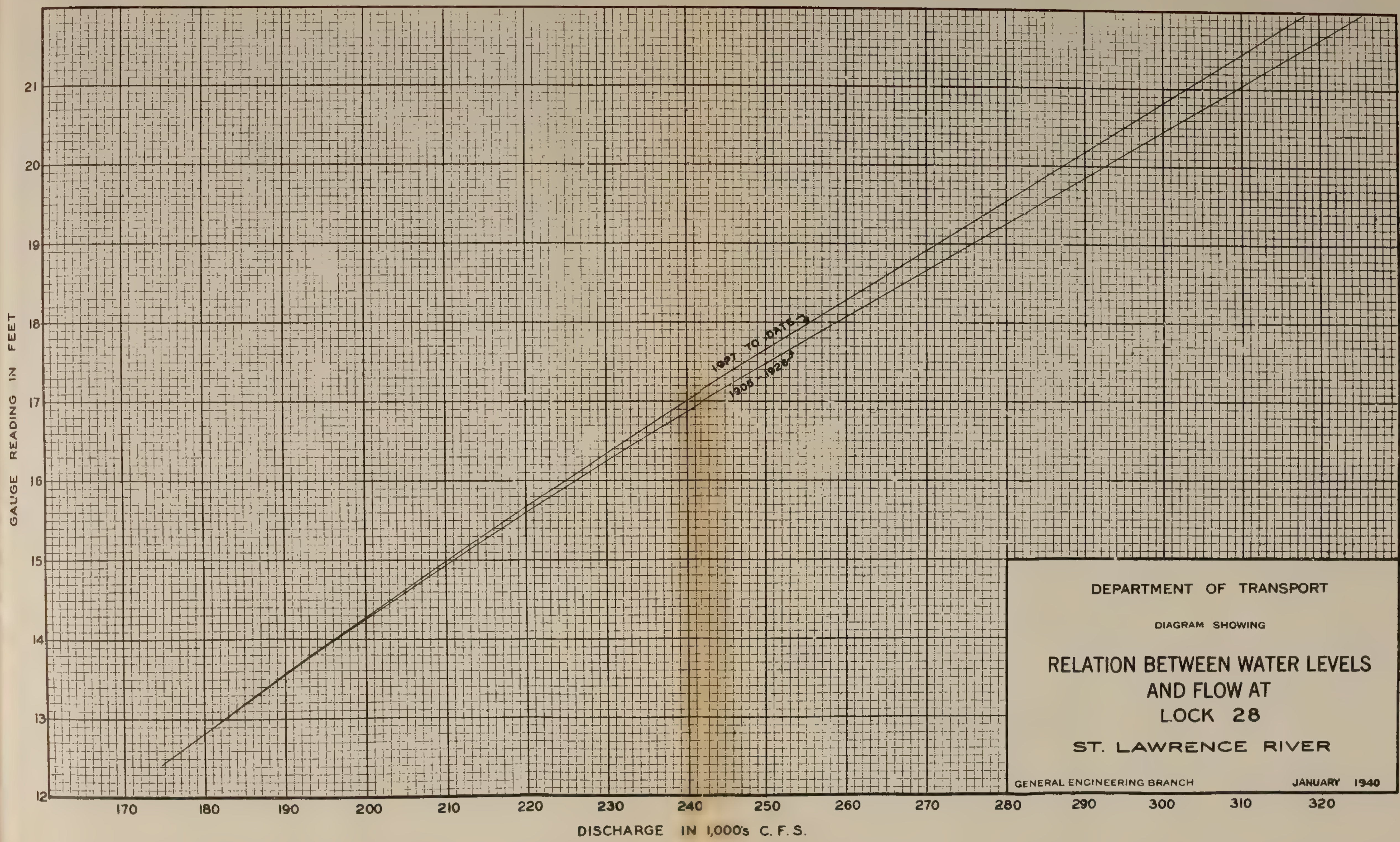
DIAGRAM SHOWING

RELATION BETWEEN WATER LEVELS AND FLOW AT LOCK 27

ST. LAWRENCE RIVER

GENERAL ENGINEERING BRANCH JANUARY 1940

PLATE NO 8



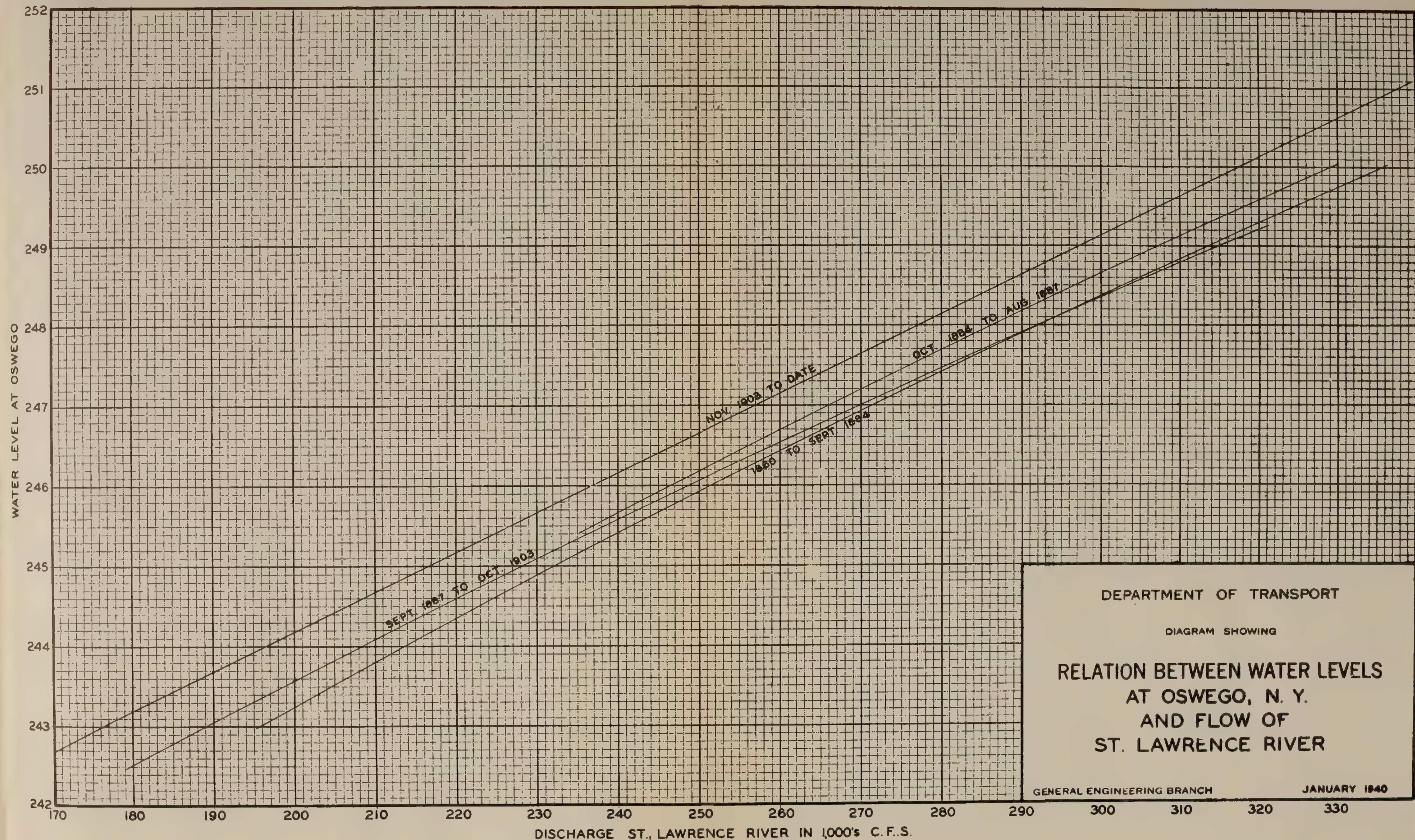
DEPARTMENT OF TRANSPORT

DIAGRAM SHOWING

RELATION BETWEEN WATER LEVELS
AND FLOW AT
LOCK 28

ST. LAWRENCE RIVER

GENERAL ENGINEERING BRANCH JANUARY 1940



252
251
250
249
248
247
246
245
244
243
242
WATER LEVEL AT OSWEGO
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
DISCHARGE ST., LAWRENCE RIVER IN 1,000's C.F.S.
NOV. 1903 TO DATE
OCT. 1884 TO AUG. 1887
1860 TO SEPT. 1884
SEPT. 1887 TO OCT. 1903
DEPARTMENT OF TRANSPORT
DIAGRAM SHOWING
RELATION BETWEEN WATER LEVELS
AT OSWEGO, N. Y.
AND FLOW OF
ST. LAWRENCE RIVER
GENERAL ENGINEERING BRANCH
JANUARY 1940

PLATE No 10

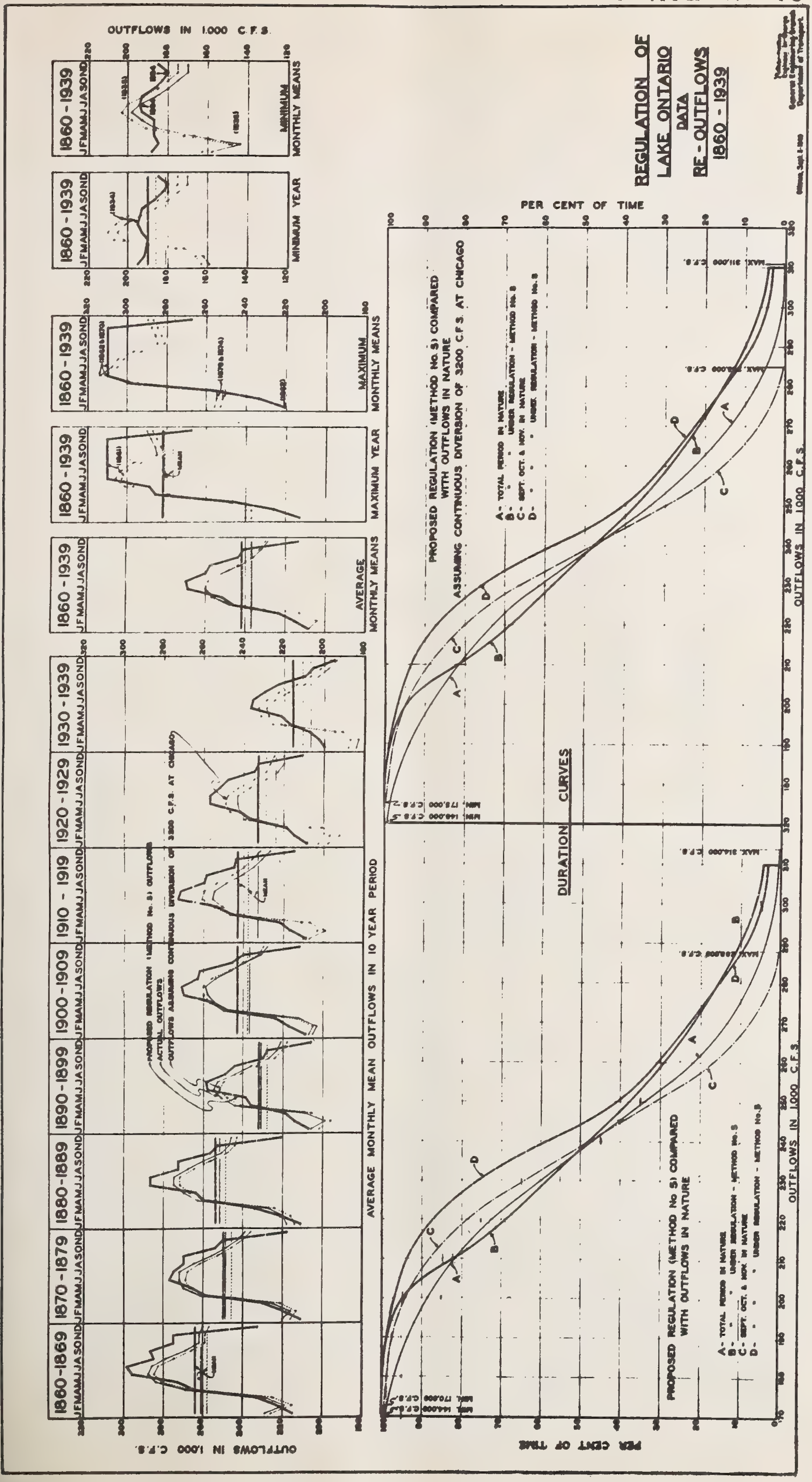
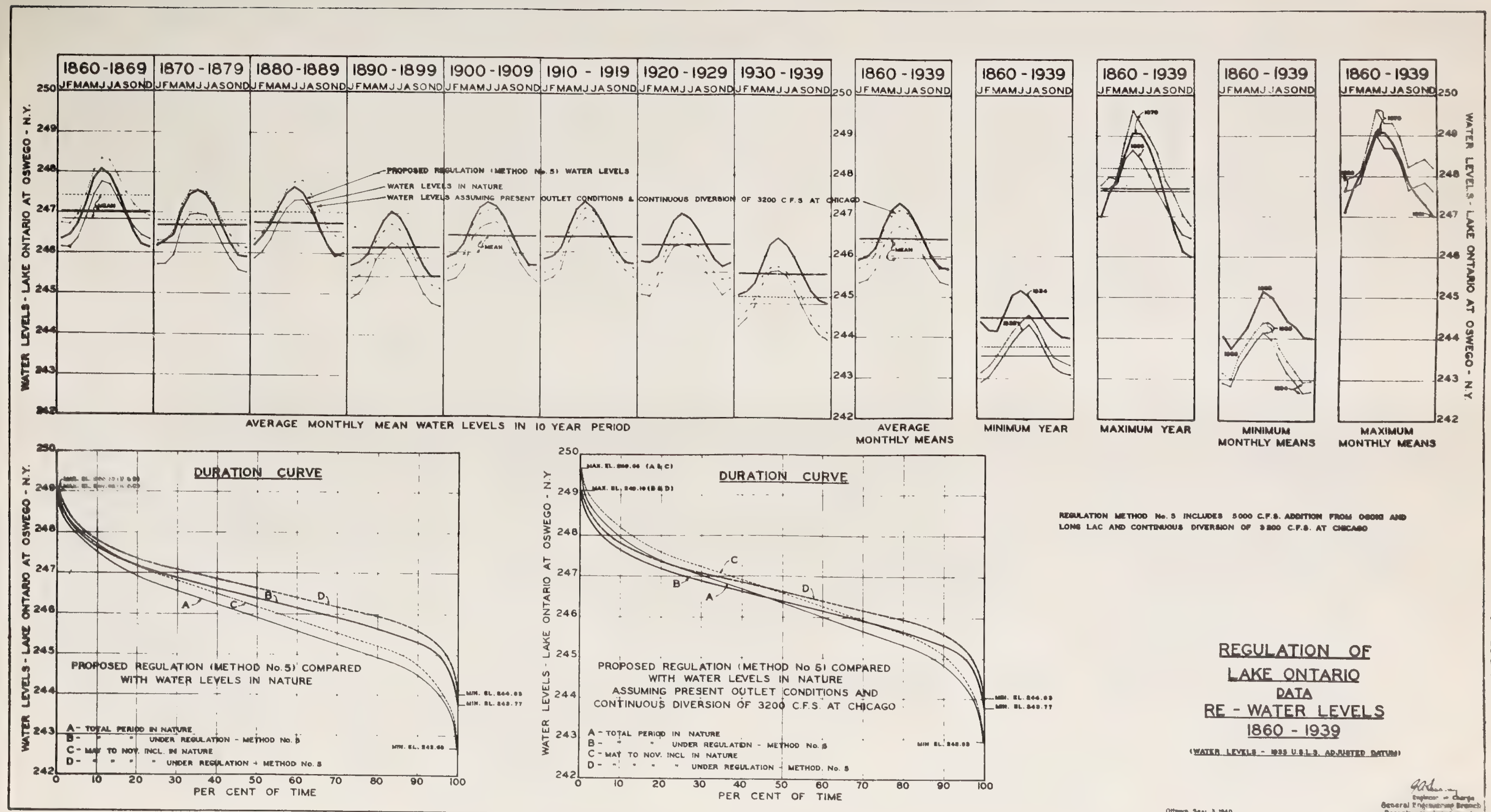
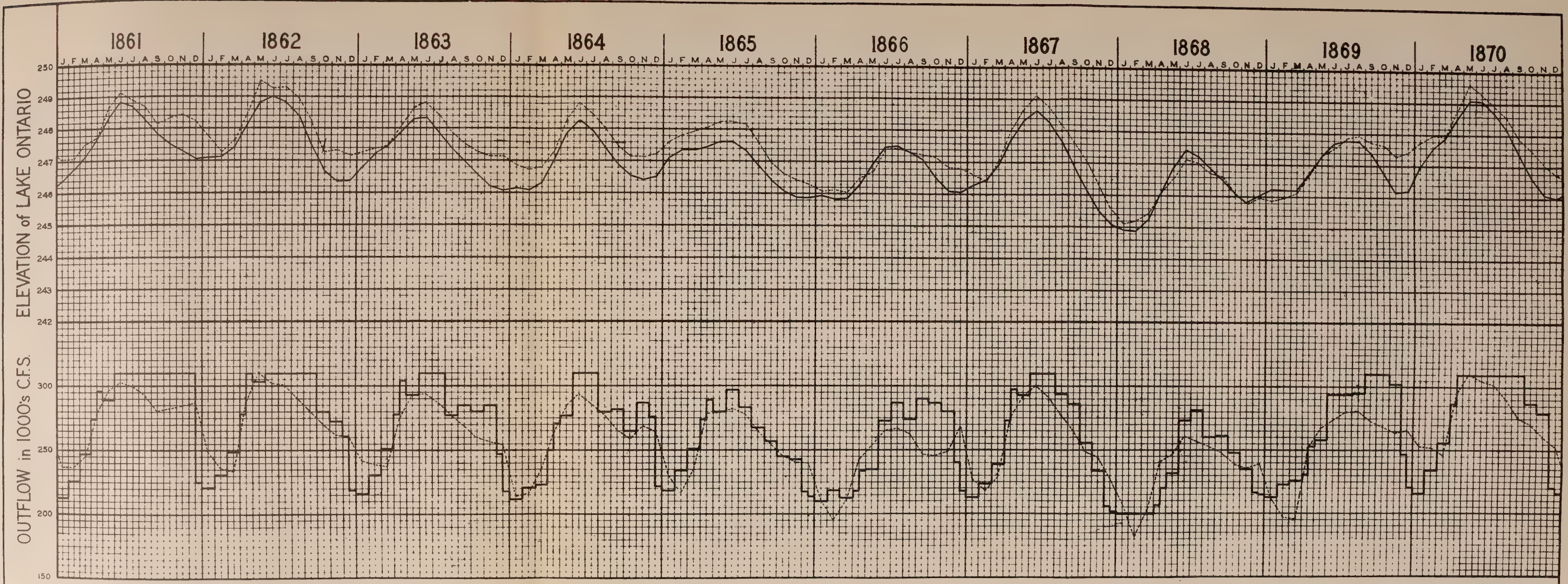

REGULATION OF
LAKE ONTARIO
DATA
RE-OUTFLOWS
1860 - 1939
OUTFLOWS IN 1,000 C.F.S.
1860-1869
1870-1879
1880-1889
1890-1899
1900-1909
1910 - 1919
1920-1929
1930-1939
JFMAMJJASOND
AVERAGE MONTHLY MEAN OUTFLOWS IN 10 YEAR PERIOD
PROPOSED REGULATION (METHOD No. 5) OUTFLOWS
ACTUAL OUTFLOWS
OUTFLOWS ASSUMING CONTINUOUS DIVERSION OF 3200 C.F.S. AT CHICAGO
MEAN
1860-1939
AVERAGE
MONTHLY MEANS
MAXIMUM YEAR
MAXIMUM
MONTHLY MEANS
MINIMUM YEAR
MINIMUM
MONTHLY MEANS
DURATION CURVES
PER CENT OF TIME
OUTFLOWS IN 1000 C.F.S.
PROPOSED REGULATION (METHOD No 5) COMPARED
WITH OUTFLOWS IN NATURE
PROPOSED REGULATION (METHOD No. 5) COMPARED
WITH OUTFLOWS IN NATURE
ASSUMING CONTINUOUS DIVERSION OF 3200 C.F.S. AT CHICAGO
A - TOTAL PERIOD IN NATURE
B - " " UNDER REGULATION - METHOD No. 5
C - SEPT. OCT. & NOV. IN NATURE
D - " " " UNDER REGULATION - METHOD No. 5
A
B
C
D

PLATE No 11



2188



LEGEND

Actual Outflow assuming 3200 c.f.s diverted continuously at Chicago ----------

Actual monthly mean Water Levels assuming 3200 c.f.s diverted continuously at Chicago, and present outlet conditions ----------

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s diverted continuously at Chicago, and 5000 c.f.s added from Ogoki and Long Lac ————

ST LAWRENCE DEEP WATERWAY

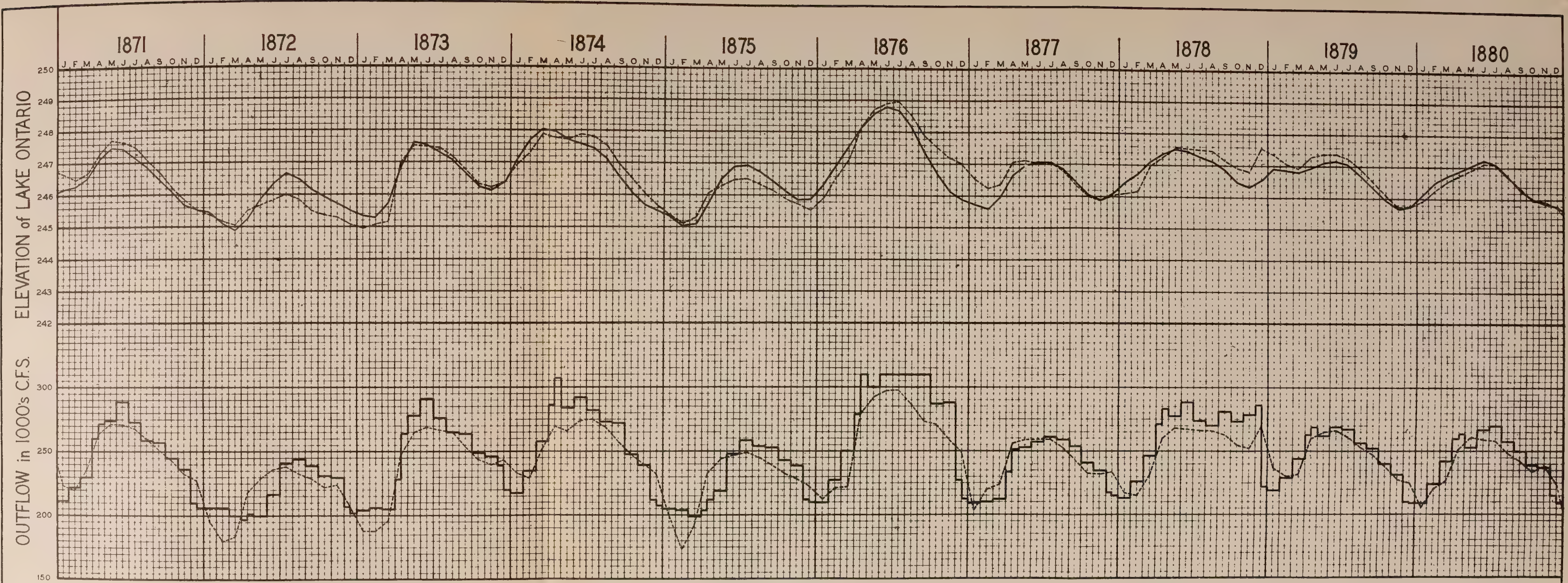
DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

METHOD NO. 5

1861 TO 1870

Dept. of Transport, General Engineering Br. Ottawa, Aug. 1940



LEGEND

Actual Outflow assuming 3200 c.f.s. diverted continuously at Chicago

Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s. diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac

ST LAWRENCE DEEP WATERWAY

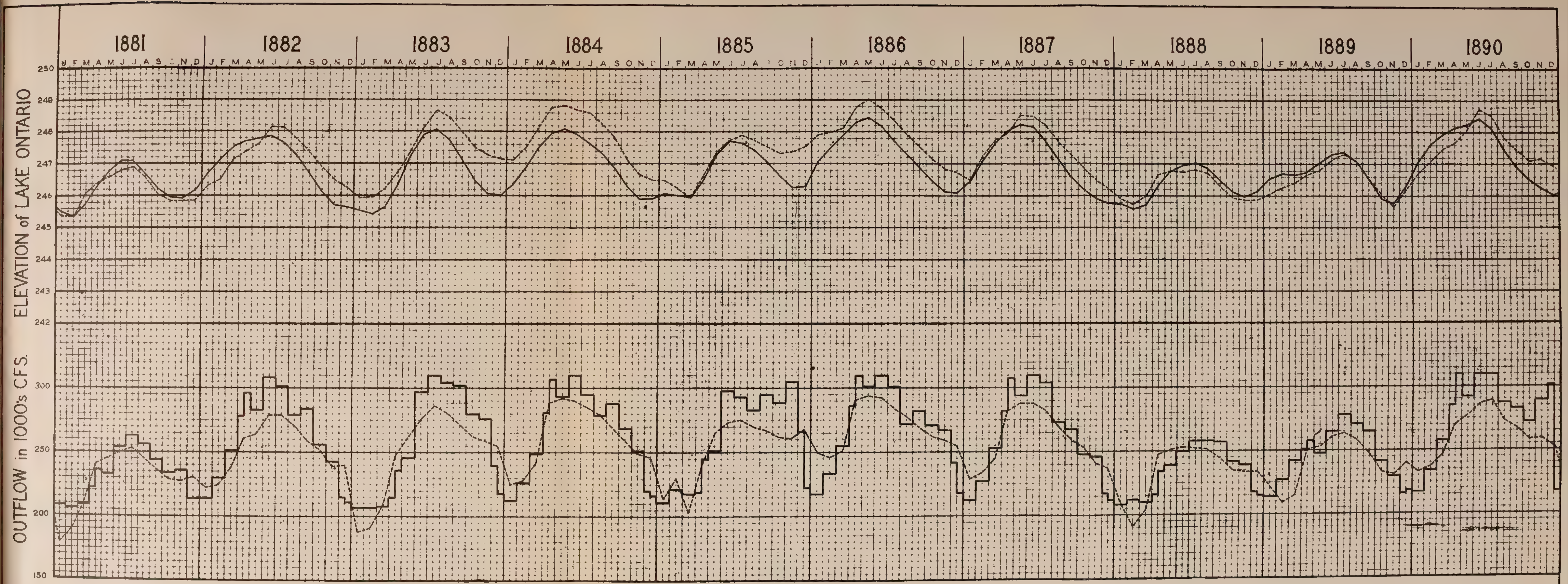
DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

METHOD NO. 5

1871 TO 1880

Dept. of Transport, General Engineering Br. *Ottawa. Aug. 1940*



LEGEND

Actual Outflow assuming 3200 c.f.s. diverted continuously at Chicago ----------

Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions ----------

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s. diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac ——————

ST. LAWRENCE DEEP WATERWAY

DIAGRAM SHOWING

• RESULTS OF REGULATION OF LAKE ONTARIO

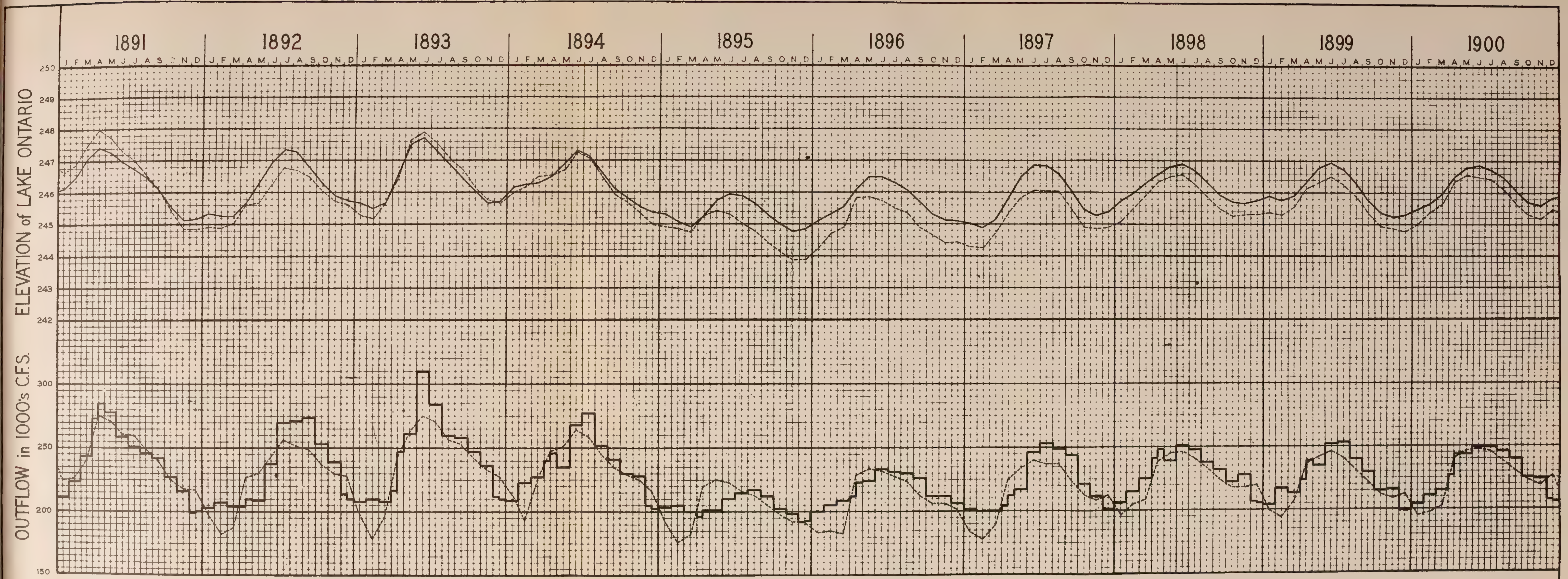
METHOD NO. 5

1881 TO 1890

Dept. of Transport,
General Engineering Br.

Ottawa, Aug. 1940.

2198. 3 OF 8



ST. LAWRENCE DEEP WATERWAY

DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

METHOD NO. 5

1891 TO 1900

LEGEND

Actual Outflow assuming 3200 c.f.s. diverted continuously at Chicago

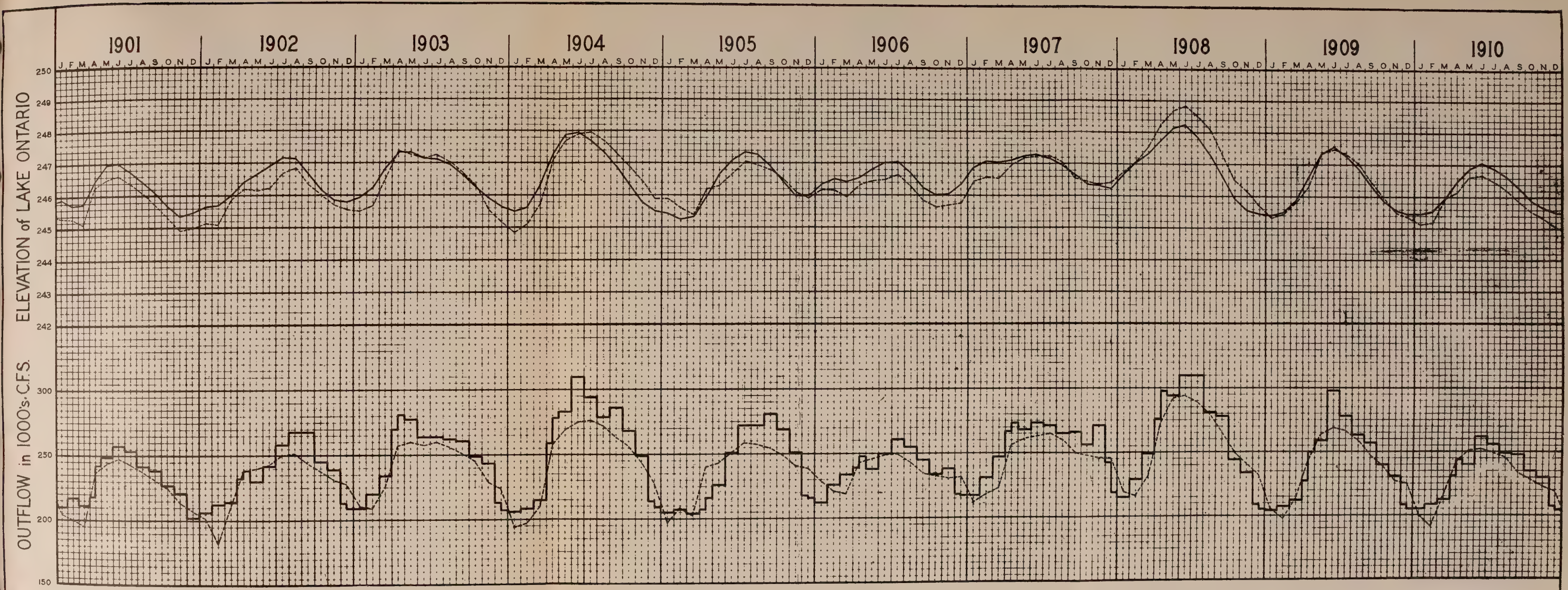
Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions

Outflow and Lake Levels, under regulation assuming 3200 c.f.s. diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac

Dept. of Transport,
General Engineering Br.

Ottawa. Aug 1940.

2198. 4 OF 8



LEGEND

Actual Outflow assuming 3200 c.f.s. diverted continuously at Chicago

Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s. diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac

ST LAWRENCE DEEP WATERWAY

DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

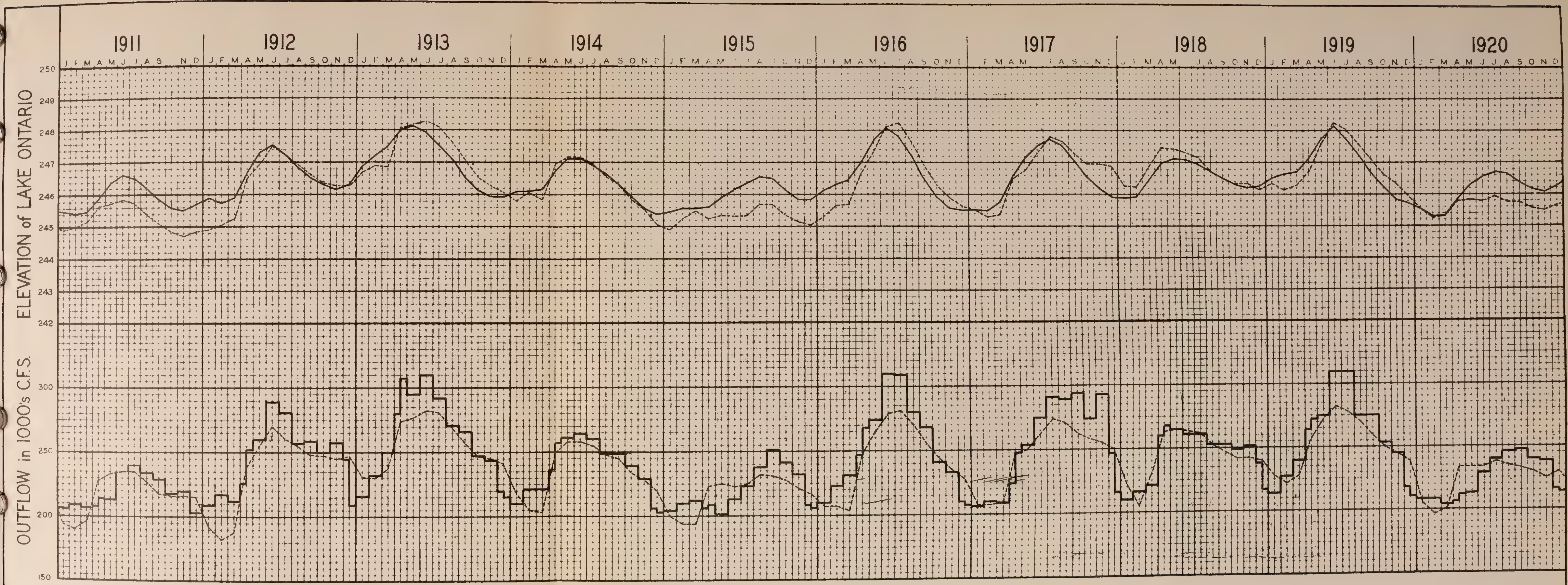
METHOD NO. 5

1901 TO 1910

Dept. of Transport,
General Engineering Br.

Ottawa, Aug 1940.

2198. 5 OF 8



LEGEND

Actual Outflow assuming 3200 c.f.s. diverted continuously at Chicago ---------

Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions ---------

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s. diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac ———

ST. LAWRENCE DEEP WATERWAY

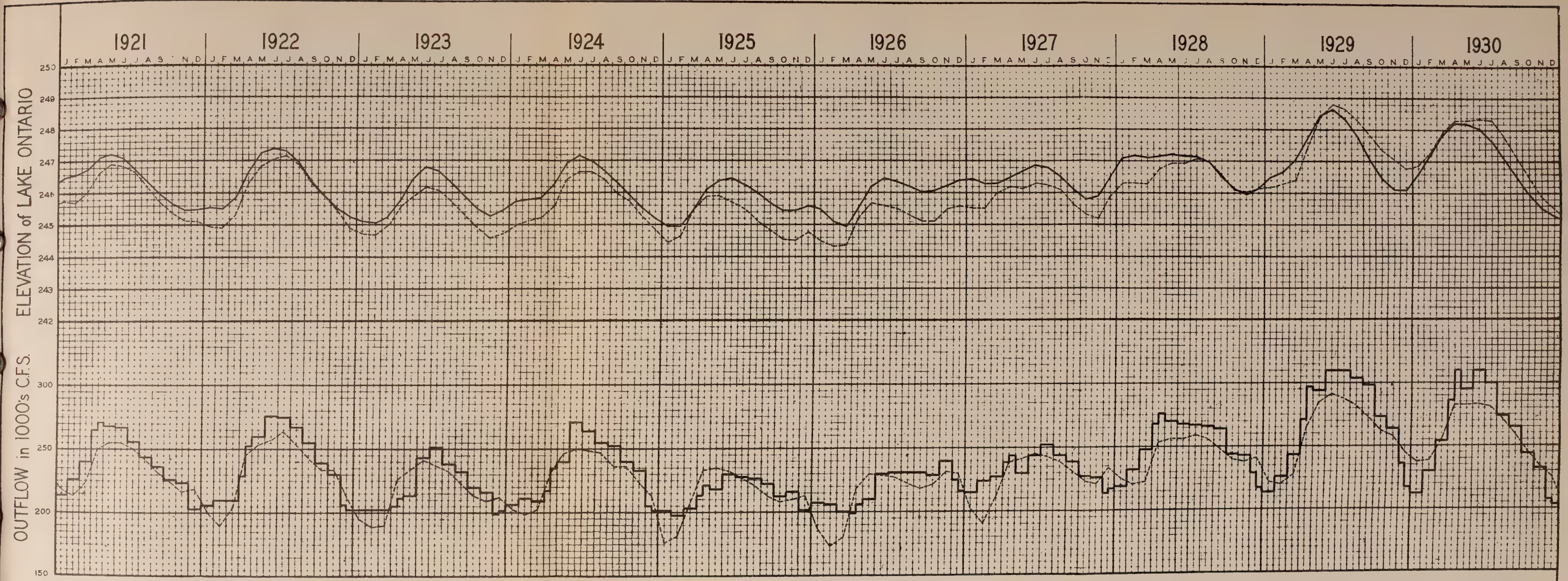
DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

METHOD NO. 5

1911 TO 1920

Dept. of Transport, General Engineering Br. *Ottawa, Aug. 1940.*



LEGEND

Actual Outflow assuming 3200 c.f.s diverted continuously at Chicago ----------

Actual monthly mean Water Levels assuming 3200 c.f.s diverted continuously at Chicago, and present outlet conditions ----------

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac ————

ST. LAWRENCE DEEP WATERWAY

DIAGRAM SHOWING

RESULTS OF REGULATION OF LAKE ONTARIO

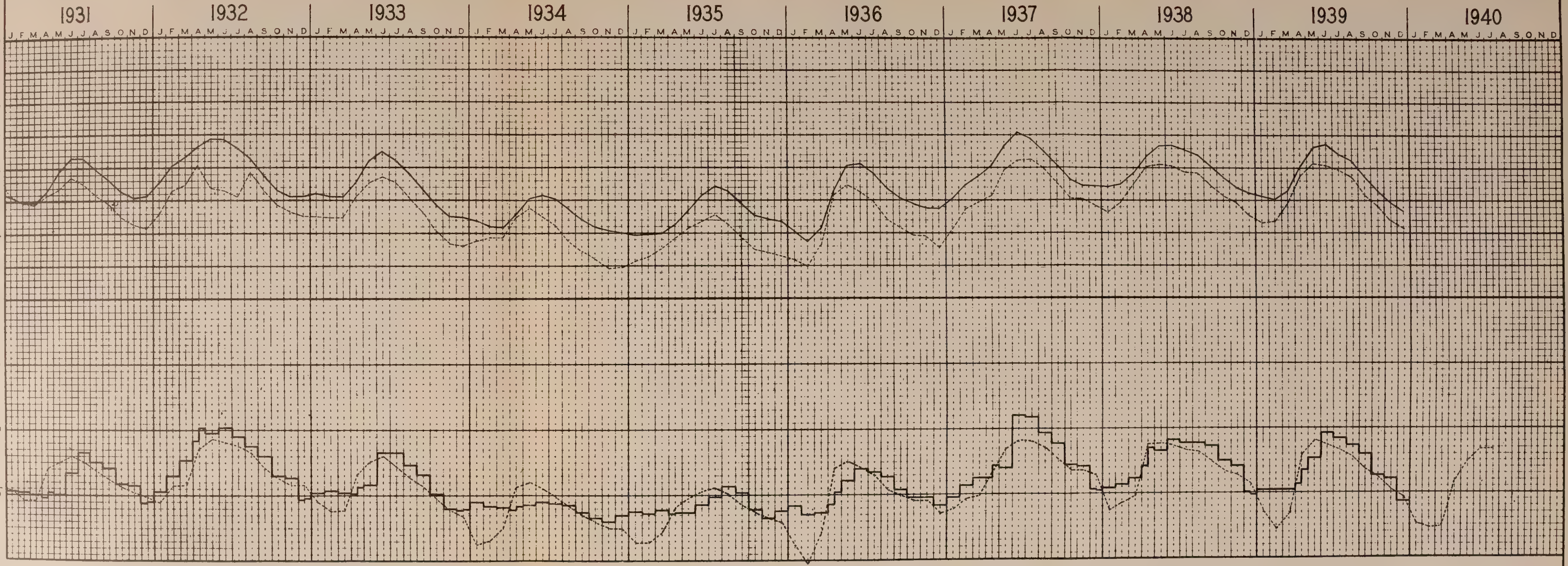
METHOD NO. 5

1921 TO 1930

Dept. of Transport, General Engineering Br.

Ottawa, Aug. 1940.

2198. 7 OF 8



LEGEND

Actual Outflow assuming 3200 c.f.s diverted continuously at Chicago ----------

Actual monthly mean Water Levels assuming 3200 c.f.s. diverted continuously at Chicago, and present outlet conditions ----------

Outflow and Lake Levels, under regulation, assuming 3200 c.f.s diverted continuously at Chicago, and 5000 c.f.s. added from Ogoki and Long Lac ———

ST LAWRENCE DEEP WATERWAY

DIAGRAM SHOWING

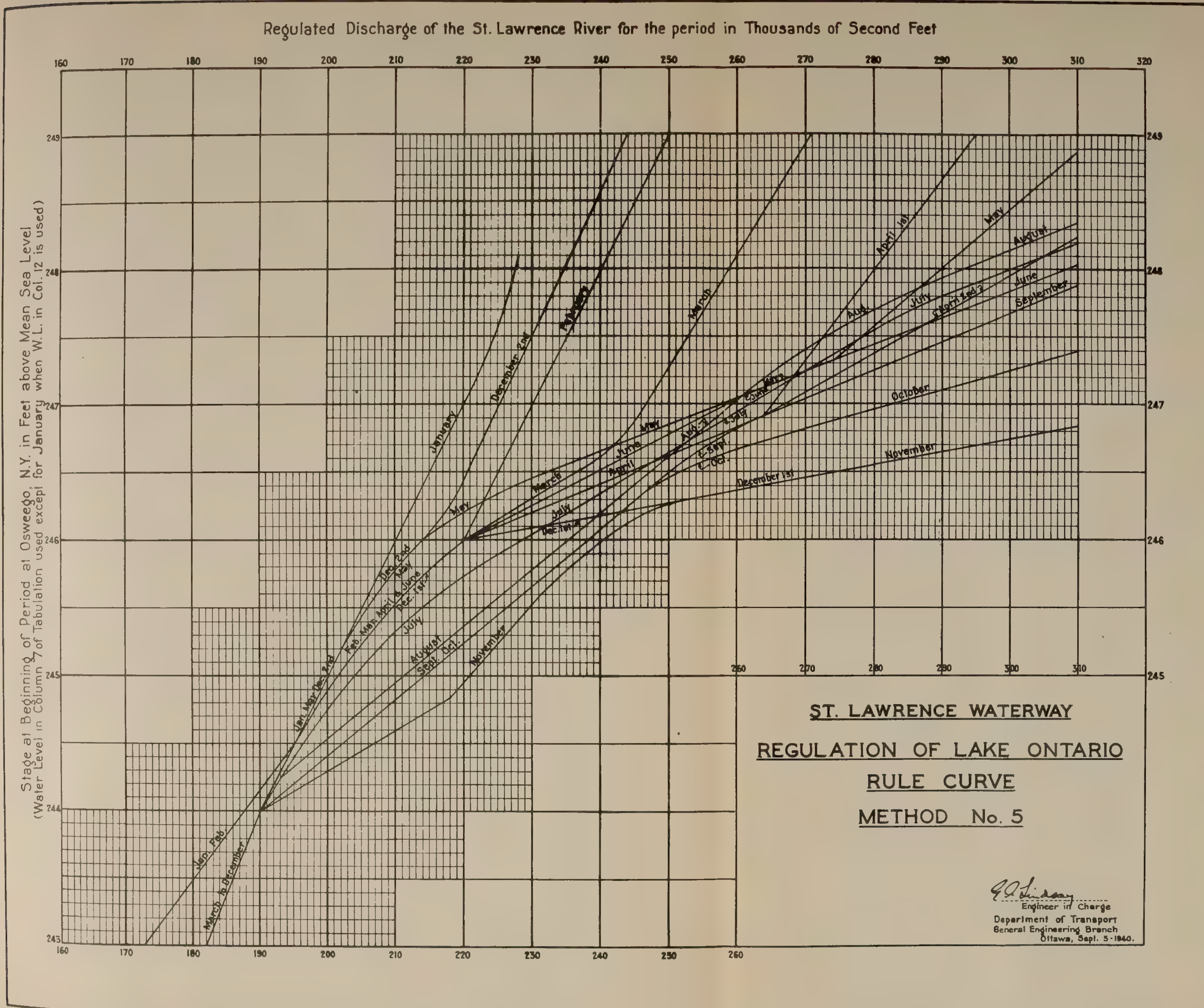
RESULTS OF REGULATION OF LAKE ONTARIO

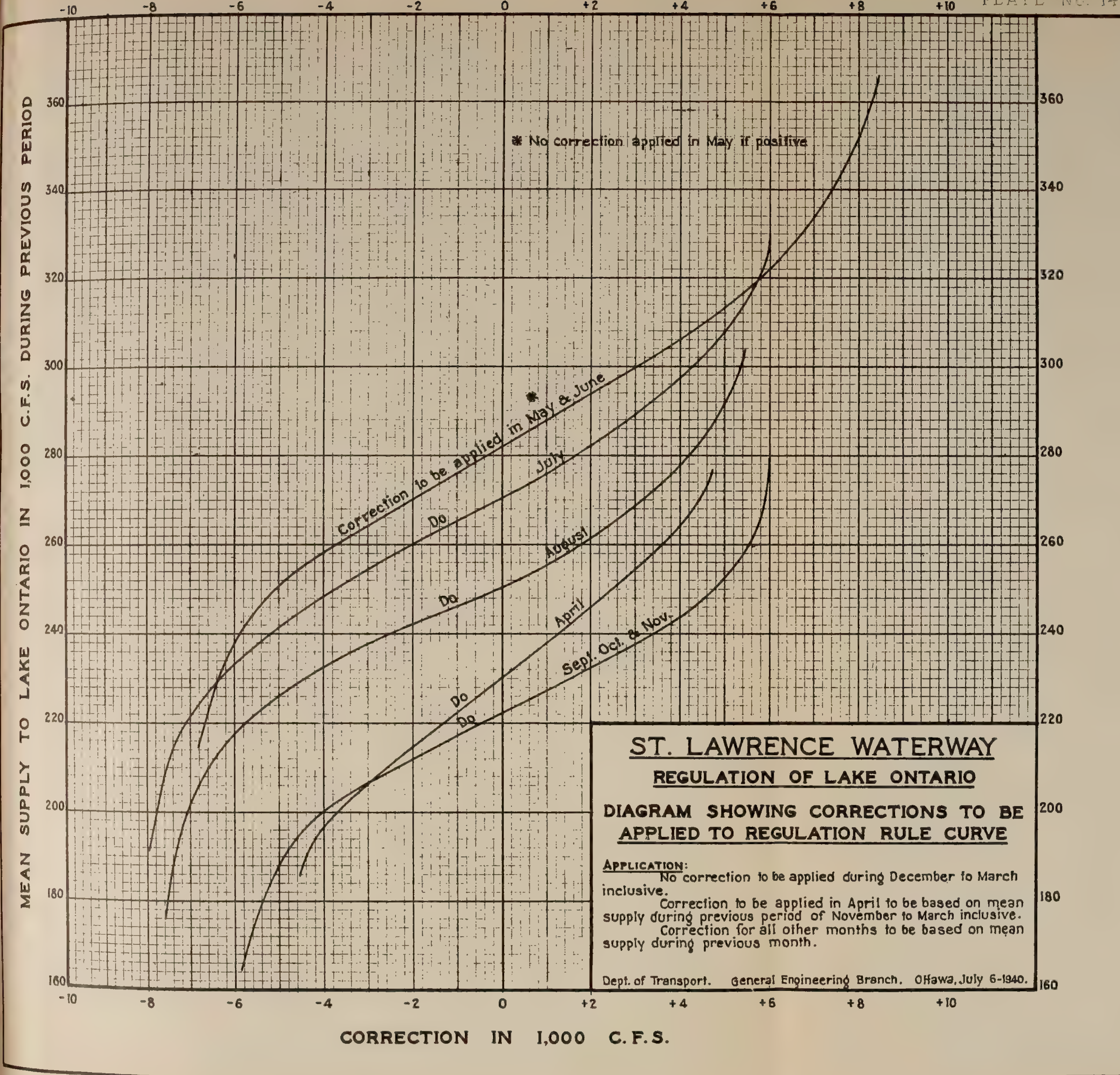
METHOD NO. 5

1931 TO 1940

Dept. of Transport,
General Engineering Br.

Ottawa, Aug. 1940.


Regulated Discharge of the St. Lawrence River for the period in Thousands of Second Feet
Stage at Beginning of Period at Oswego, N.Y. in Feet above Mean Sea Level
(Water Level in Column 7 of Tabulation used except for January when W.L. in Col. 12 is used)
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
243
244
245
246
247
248
249
January
December 2nd
February
March
April 1st
May
August
July
June
September
October
November
December 1st
Jan. Feb.
March to December
Jan. May Dec. 2nd
Feb. Mar. April & June
Dec. 2nd
Dec. 1st
July
August
Sept. Oct.
November
ST. LAWRENCE WATERWAY
REGULATION OF LAKE ONTARIO
RULE CURVE
METHOD No. 5
Engineer in Charge
Department of Transport
General Engineering Branch
Ottawa, Sept. 5-1940.


* No correction applied in May if positive
Correction to be applied in May & June
Do July
Do August
Do April
Do Sept. Oct. & Nov.
MEAN SUPPLY TO LAKE ONTARIO IN 1,000 C.F.S. DURING PREVIOUS PERIOD
CORRECTION IN 1,000 C.F.S.
ST. LAWRENCE WATERWAY
REGULATION OF LAKE ONTARIO
DIAGRAM SHOWING CORRECTIONS TO BE APPLIED TO REGULATION RULE CURVE
APPLICATION:
No correction to be applied during December to March inclusive.
Correction to be applied in April to be based on mean supply during previous period of November to March inclusive.
Correction for all other months to be based on mean supply during previous month.
Dept. of Transport. General Engineering Branch. Ottawa, July 6-1940.

PART THREE

HORIZONTAL AND VERTICAL CONTROL DATA


6

ST. LAWRENCE RIVER PROJECT

Horizontal and Vertical Control Data

1. Following are descriptions of horizontal control monuments used on this survey. Geographic coordinates shown are based on North American datum. Plane coordinates shown are based on the Transverse Mercator Coordinates (East Zone) for the State of New York. Descriptions of the International Waterways Commission Monuments were taken from Mr. Hefty's Report noted in Chapter II of the main report. The International Boundary Commission Reference Monuments are concrete monuments as shown on the attached photograph. Descriptions of U. S. Lake Survey monuments were taken from the list noted in Chapter II of the main report.

a. Description of Primary Horizontal Control Monuments.

I.B.C. 1 - On East end of Cornwall Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-33.685 X. 412,602.89)
(Long. 74-40-16.476 Y. 1,825,734.72)

I.B.C. 2. - On East end of Cornwall Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-10.254 X. 411,623.04)
(Long. 74-40-29.975 Y. 1,823,365.79)

I.B.C. 3 - On East end of Cornwall Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-02.468 X. 409,488.05)
(Long. 74-40-59.641 Y. 1,822,586.38)

I.B.C. 4 - On the South central part of Cornwall Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-15.269 X. 404,443.05)
(Long. 74-42-09.934 Y. 1,823,905.18)

I.B.C. 5 - On the south central part of Cornwall Island. It is an International Boundary Commission Reference Monument.
(Lat. 44-59-59.204 X. 399,262.16)
(Long. 74-43-21.931 Y. 1,822,302.40)

I.B.C. 6 - On the south side of Cornwall Island just east of the N. Y. and O. R. R. bridge. It is an International Boundary Commission Reference Monument.
(Lat. 44-59-30.135 X. 396,790.08)
(Long. 74-43-56.132 Y. 1,819,370.40)

I.B.C. 7 - On the south side of Cornwall Island, just west of the N. Y. and O. R. R. bridge. It is an International Boundary Commission Reference Monument.
(Lat. 44-59-30.089 X. 393,817.52)
(Long. 74-44-37.494 Y. 1,819.380.63)

I.B.C. 8 - On the west end of Cornwall Island. An International Boundary Commission Reference Monument.
(Lat. 44-59-44.785 X. 389,906.09
(Long. 74-45-32.029 Y. 1,820,889.22

I.B.C. 9 - On Cornwall Canal Dike, just east of Lock 19. An International Boundary Commission Reference Monument.
(Lat. 45-00-32.075 X. 388,424.91
(Long. 74-45-52.996 Y. 1,825,686.41

I.W.C. 21 = U.S.L.S. 16. - On the north bank of the St. Lawrence River about 400 meters west of lock 19 of the Cornwall Canal; on the natural bank of the River and below the berm of the canal; about 2 meters back from the edge of the river bank and about 2 meters east of a large ditch. It is an International Boundary Commission standard bronze-disk station mark set flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 30 inches in depth. The sub-surface mark is the original drill hole surrounded by a triangle cut in a flat rock 30 inches underground. Reference mark No. 1 is a drill hole in the top of the most westerly of a group of large rocks in azimuth 108° 59' distant 21.69 meters from the station. Reference mark No. 2 is a drill hole in the top of a very large flat topped rock in azimuth 267° 54', distant 60.34 meters from the station. Reference mark No. 2 is the point occupied as "Lacombe".
(Lat. 45-00-32.904 X. 384,256.56)
(Long.74-46-51.021 Y. 1,825,792.95)

U.S.L.S. 17 (1872). - Is on the American side of the river just below the foot of Barnhart Island, 600 feet from the shore, 490 feet S. of road to Massena Pt. and on the farm of Andrew Snow. It is 165 feet E. of Snow's barn, 138.0 feet N. of a 3/4" drill hole in a 8 x 5 x 2 foot high boulder, 115.4 feet N. W. of a 3/4" drill hole in a flat 4 x 5 foot boulder, 127.3 feet E. of a well pump, and 85.7 feet N. E. of a metal tablet, set in concrete, bearing the name U. S. Lake Survey and an arrow which points 30° to the right of a line to the station. This tablet is in a fence line and is E. of and on line with the north side of Snow's house. The station mark is the center hole of a triangle cut in a stone set 3 feet below the ground surface.
(Lat. 44-59-51.345 X. 381,973.88)
(Long.74-47-22.463 Y. 1,821,596.72)

I.B.C.10 - On the east end of Barnhart Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-15.077 X. 379,306.69)
(Long. 74-47-59.773 Y. 1,824,015.47)

I.W.C. 22. - On the most eastern end of Barnhart Island, on the first high ground west of the shore line. In the flat top of a conspicuous lone rock about 6 x 8 feet in size and 5 feet high. It is an International Boundary Commission standard bronze-disk.
(Lat. 45-00-26.106 X. 379,762.71)
(Long. 74-47-53.515 Y. 1,825,129.80)

I.B.C. 11. - On Cornwall Canal Dike just below lock 20. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-52.802 X. 379,249.14)
(Long. 74-48-00.880 Y. 1,827,836.48)

I.W.C. 36. - On Barnhart Island, about 900 meters east of the west end of the island and about 275 meters south of the north shore of the island. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a large rock. The subsurface mark is a brass screw set in a drill hole in a rock 30 inches underground. Reference mark No. 1 is a drill hole and cross cut in the top of a conical rock projecting 6 inches above the surface of the ground in azimuth 128° 27', distant 4.288 meters from the station. Reference mark No. 2 is a drill hole and cross cut in the top of a rounded boulder, 2 feet across and 8 inches above the surface of the ground, under an elm tree with low and heavy twisted branches, and in azimuth 59° 15', distant 6.154 meters from the station.
(Lat. 45-00-09.402 X. 365,810.99)
(Long. 74-51-07.550 Y. 1,823,522.77)

I.B.C. 15. - On the west end of Barnhart Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-07.667 X. 363,800.86)
(Long. 74-51-35.511 Y.1,823,360.02)

I.W.C. 38. - On Barnhart Island, about 150 meters from the west end of the island, on a point of the north shore-line just west of a slough and ravine. The station is about 15 meters back from the edge of the high bank of the river. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in a large rock. The subsurface mark is a brass screw set in a drill hole in a rock 30 inches underground. Reference mark No. 1 is a drill hole and cross cut on a rock 3 x 2½ feet in size by 1 foot high in azimuth 281° 48', distant 11.698 meters from the station. Reference mark No. 2 is a drill hole and cross cut on a rock 4 x 4 x 2 feet high in azimuth 326° 23', distant 26.393 meters from the station.
(Lat. 45-00-13.238 X. 363,749.82)
(Long. 74-51-36.272 Y. 1,823,924.53)

I.B.C. 16 = I.W.C. 41. - On the west end of Sheek Island. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-14.740 X. 358,928.38)
(Long. 74-52-43.389 Y. 1,824,108.54)

I.B.C. 17. - On Cornwall Canal dike at head of Long Sault Rapids. It is an International Boundary Commission Reference Monument.
(Lat. 45-00-09.449 X. 356,470.491)
(Long. 74-53-17.546 Y. 1,823,589.41)

I.W.C. 48. - On Long Sault Island, on a prominent point of the north shore line of the island about 2700 meters west of the east end of the island and nearly due south of lock 21 of the Cornwall canal. The station is about 1½ meters back from the edge of the high bank of the river and about 30 meters north of a group of large elm trees. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 28 inches in depth. The subsurface mark is a brass screw set in a circular block of concrete 28 inches underground. Reference mark No. 1 is a drill hole and cross cut on the northern side of a rock outcrop 4 by 3 feet in size and 2 feet high about 7½ meters back from the top of the river bank, in azimuth 259° 09', distant 10.388 meters from the station. Reference mark No. 2 is a drill hole and cross cut on the northeastern end of an outcrop of shale rising about 2½ feet above the ground with a perpendicular side facing away from the river at a distance of about 9 meters from the top of the river bank. The mark is in azimuth 356° 29', distant 10.406 meters from the station. Reference mark No. 3 is a shallow drill hole and a scratched cross on a flat outcrop of rock about 1½ meters back from the edge of the river bank in azimuth 18° 34', distant 9.930 meters from the station.
(Lat. 44-59-31.458 X. 353,297.45)
(Long. 74-54-01.331 Y. 1,819,763.65)

I.B.C. 19. - On Long Sault Island. It is an International Boundary Commission Reference Monument.
(Lat. 44-58-57.931 X. 351,386.87)
(Long. 74-54-27.582 Y. 1,816,381.48)

I.W.C. 50. - On Long Sault Island, on a sharp and prominent point of the north shore line of the island, directly opposite Wagner Island. The station is within 3 meters of the edge of the high bank of the river. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 30 inches in depth. The subsurface mark is a brass screw set in a circular block of concrete 30 inches underground.
(Lat. 44-58-57.372 X. 349,530.16)
(Long. 74-54-53.408 Y. 1,816,338.14)

I.B.C. 21. - On North Central side of Croil Island. It is an International Boundary Commission Reference Monument.
(Lat. 44-58-52.501 X. 334,502.05)
(Long. 74-58-22.432 Y. 1,815,957.95)

I.B.C. 78-sub. - About 5 miles above Louisville Landing, in a cultivated field on the north side of N. Y. highway No. 37-B, 5 meters from the north fence line of the highway. The station is about 45 meters westerly from a brush covered fence running from the highway fence to the river, and about 9 meters easterly from a large tree standing in the north fence line of the highway. The station being in a cultivated field there is no surface mark. The subsurface mark is a standard I.B.C. bronze-disk station mark set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth set 24 inches underground. Reference mark No. 1 is a standard I.B.C. bronze-disk with an arrow pointing toward the station cut on it set in a triangular shaped rock $2\frac{1}{2}$ feet on a side and 1 foot high situated in the fence line running from the highway to the river, at a distance of 60 meters from the highway and 3 meters southernly from a large elm tree. Reference mark No. 2 is a like disk with an arrow cut on it set in a rock $2\frac{1}{2}$ by $2\frac{1}{2}$ feet and 1 foot high standing in the line of trees on the south side of the highway and 1 meter east of the most westerly of the large trees in the row. Reference mark No. 3 is the westerly corner of the concrete post bearing the historic marker of "First Protestant Church in Canada".
(Lat. 44-54-54.574 X. 302,179.48)
(Long. 75-05-48.950 Y. 1,792,140.01)

I.W.C. 90. U.S.L.S. Allison. - About 3-1/4 miles east of Waddington, New York, on the prominent point (Nichols Point) on the south shore of the St. Lawrence River due south of Doran Island. The station is among the sand dunes on the highest part of the point. It is about 300 meters north of New York highway No. 37. It is east of and in line with the north face of a gray cottage; about 2 meters south of the range of a title chimney on a yellow cottage and the west gable window of a brick house; and is about 100 meters northwest of a fence corner. It is a standard International Boundary Commission bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 34 inches in depth. There are 2 references, each a standard U. S. Lake Survey bronze-disk reference mark with the arrow pointing toward the station set nearly flush with the ground in the top of a cylinder of concrete about 8 inches in diameter and encased in sheet-iron.
(Lat. 44-53-29.124 X. 288,855.54)
(Long. 75-08-52.895 Y. 1,783,614.93)

I.B.C. 91-sub. - At lock 23 at the lower end of the Morrisburg Canal, on the embankment between the old or unused lock and the lock now in use. It is 28 meters west of the east end of the embankment between the two locks, 3½ meters south of the concrete wall on the south side of the north or old lock, 8 meters north of the steps leading down from the north wall of the south or used lock, and 3 meters west of the first cast-iron snubbing post appertaining to the north lock. It is an International Boundary Commission bronze-disk station mark set flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in a mass of concrete attached to a large rock, 24 inches underground. Reference mark No. 1 is the southeastern corner of the concrete wall and walk at the head of the stairs leading down from the north or unused lock. Reference mark No. 2 is the northwest corner of the concrete walk at the head of the stairs leading down from the north wall of the south or used lock. Reference mark No. 3 is the center of the first cast-iron snubbing post on the high level on the north side of the south or used lock.
(Lat. 44-53-36.702 X. 281,655.48)
(Long. 75-10-33.020 Y. 1,784,455.90)

U.S.L.S. Waddington (1872). - On the American side of the river 1-1/2 miles below Waddington; 680 feet south of a concrete highway bridge; 260 feet S.E. of Little Sucker Brook; on top of a high bank; and 50 feet S. of the wood line. It is 60 feet N. E. of a wire fence line; 53 feet S. E. of a metal tablet set in concfete bearing the name U.S. Lake Survey and an arrow which points to the station; 67 feet N. E. of 20" Oak tree; and 113.5 feet N.W. of an 18" Hickory tree. The Station mark is the 1" drill hole in a 15" x 18" stone, set 3-1/2 feet below the surface of the sandy soil.
(X. 281,128.12)
Y. 1,778,022.34)

I.B.C. 35. - On the northeast end of Ogden Island. It is an International Boundary Reference Monument.
(Lat. 44-52-54.349 X. 276,892.11)
(Long. 75-11-38.556 Y. 1,780,216.21)

I.W.C. 95. - About 3/4 mile west of Morrisburg, on the dyke of the Morrisburg canal between the canal and the river, 1-1/8 miles above lock No. 23. Thestation is about the middle of the dyke and directly opposite the lower end of Ogden Island. It is an International Boundary Commission bronze-disk station mark set nearly flush with the grouhd in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole in a rock showing 1-1/2 by 1-1/2 feet by 6 inches high above grouhd on the top of the bank on the river side of the dyke and on line from the station to the southern tangent of Canada Island. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a boulder 4 by 4 by 3 feet on the top of the high bank on the river side of the dyke.
(Lat. 44-53-05.002 X. 276,216.66)
(Long. 75-11-48.096 Y. 1,781,302.36)

I.W.C. 97. - About 1 mile west of Morrisburg, on the embankment of the Morrisburg canal between the canal and the river, at a wide place on the embankment about 100 meters east of the southern bend of the canal. It is an International Boundary Commission bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a conspicuous boulder 4 by 4 by 3 feet in size near the middle of the canal dyke and on line from the station to the center of Canada Island. Reference mark No. 2 is a drill hole in a rock showing 1-1/2 by 1-1/2 by 1 feet above ground at about 2 meters north of the top of the bank on the river side of the dyke. Reference mark No. 3 is the center of the first cast-iron snubbing post east of Monument 36.
(Lat. 44-52-54.372 X. 275,016.13)
(Long. 75-12-04.611 Y. 1,780,238.59)

I.B.C. 38. - Ogden Island. It is an International Boundary Commission Reference Monument.
(Lat. 44-52-02.280 X. 267,935.72)
(Long. 75-13-42.136 Y. 1,775,039.35)

I.W.C. 106. - On the western end of Ogden Island in the St. Lawrence River, about 450 meters from the extreme west end of the island and 100 meters south of the north shore of the island. The station is in open pasture land, in azimuth 310° 13', 90.5 meters distant from Boundary Reference Monument No. 39. There is a row of trees about 120 meters south of the station, and a red cottage is to be seen about 200 meters to the east of the station. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock showing 4 by 5 feet 18 inches high above ground to the northeast of the station. Reference mark No. 2 is a like mark cut on a rock of about the same size to the northwest of the station.
(Lat. 44-51-56.661 X. 265,022.25)
(Long. 75-14-22.499 Y 1,774,502.51)

I.B.C. 103-sub. - At the head of the Morrisburg canal, on the broad part of the dyke between the canal and the St. Lawrence River, about 75 meters southwest of the watergate and lock 24, about 13 meters northeast of where the dyke narrows, about 10 meters toward the canal from the river bank of the dyke. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is the 2nd cast-iron snubbing post

west of lock 24. Reference mark No. 2 is the first cast-iron snubbing post west of lock 24. Reference mark No. 3 is a drill hole and an arrow pointing toward the station cut in a rock 3 by 3 feet by 1-1/2 feet high on the dyke west of the lock.
(Lat. 44-52-13.393 X. 265,601.64)
(Long. 75-14-14.719 Y. 1,776,190.72)

U.S.L.S. Ames (1872). - Is located about 2 miles above Waddington, N. Y. and 1/4 mile S. of the river. It is in a rock strewn field, about 830 feet W.S.W. of a road intersection; about 180 feet S. of the river road; and 9 feet E. of a rail fence on the E. edge of an orchard. It is 38.6 feet S.W. of a cross cut in a 3 by 4 by 1-1/2 foot high boulder; 42.6 feet E.S.E. of a 3 by 5 by 1-1/2 foot high boulder on the W. side of the fence; 119.2 feet S.E. of a cross cut in a 3 by 4 by 1 foot high boulder S. of the road fence; and 18 feet N. of an 18 inch elm tree in a fence line. The elevation above the river is about 40 feet. The station mark, established in 1872, is a drill hole in a stone below the ground surface. The surface mark is a 1 inch triangular drill hole in a stone block, 5 inches square, centered over the station mark and about 1/2 foot below the ground surface.
(X. 264,776.59)
(Y. 1,769,837.80)

I.W.C. 108. - About 2 miles west of Waddington, about 400 meters upstream from the extreme tip of Leishman Point on the south shore of the St. Lawrence River. The station is about 23 meters back from the shore of the river and 90 meters northwest of an old house. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 2 feet by 1½ feet high 8 meters back from the edge of the high bank of the river. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a rock 4 by 5 feet by 2 feet high on slightly higher ground about 60 meters back from the edge of the high bank of the river.
(Lat. 44-51-31.227 X. 262,367.79)
(Long. 75-14-58.951 Y. 1,771,956.21)

I.B.C. 40. - At Point Three Points, opposite Leishman Point. It is an International Boundary Commission Reference Monument.
(Lat. 44-51-38.658 X. 260,387.80)
(Long. 75-15-26.558 Y. 1,772,731.25)

I.W.C. 107-sub. - It is on the north shore of the St. Lawrence River about 4 miles west of Morrisburg and about 1/2 mile west of the upper end of Ogden Island. The station is about 6 meters back from the edge of the high bank of the river at a point where a boathouse extends from the high bank to the water's edge. It is an International Boundary Commission standard bronze-disk station mark set nearly flush

with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of an irregular mass of concrete poured between some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a boulder 3 by 3 feet by 1 foot high on the edge of the high bank of the river 3 meters west of the boat-house. Reference mark No. 2 is International Boundary Reference Monument No. 40.
(Lat. 44-51-38.357 X. 260,459.08)
(Long. 75-15-25.563 Y. 1,772,699.96)

U.S.L.S. Jinks (1872). - Is located about 3½ miles above Waddington, N. Y. about 1 mile S.E. of the river, and about 530 feet N. of the river road. It is on a bare hill about 130 feet N.E. of its highest part; 40 feet W. of a stone wall; and 76 feet N. of another stone wall. It is 201.4 feet S.E. of a cross cut in a 5 by 2 foot high triangular shaped boulder; and 179.5 feet E.N.E. of a cross cut in a 3½ by 1 foot high boulder. The elevation above the river is about 60 feet. The station mark, established in 1872, is a drill hole in a stone, 1 foot square, set about 3 feet below the ground surface. The surface mark is a 1 inch drill hole in a stone block, 5 inches square, centered over the station mark and about 1 foot below the ground surface.
(X. 258,271.99)
(Y. 1,764,012.74)

I.W.C. 117-sub. - At Iroquois on the outer pier of lock 25 at the outlet of the Galop Canal. The station is on the stone seawall around the outer end of the pier and near the southeastern part of the semi-circular end of the pier. It is an International Boundary Commission standard bronze-disk station mark set in a drill hole in the deck of the stone seawall. Reference mark No. 1 is the center of the cast-iron snubbing post near the end of the pier. Reference mark No. 2 is a drill hole in the top surface of the seawall on the northern side of and near the eastern end of the pier.
(Lat. 44-50-24.436 X. 246,927.90)
(Long. 75-18-32.170 Y. 1,765,370.98)

I.B.C. 43. - North end of Iroquois Point. It is an International Boundary Commission Reference Monument.
(Lat. 44-50-07.141 X. 246,331.62)
(Long. 75-18-40.153 Y. 1,763,626.46)

I.W.C. 119-sub. - About 3/4 mile south of Iroquois, on the southeastern shore of Iroquios Point on the north shore of the St. Lawrence River. The station is about 4 feet above the normal water level of the river and about 5 meters from the water's edge. It is an International Boundary Commission standard bronze-disk station mark set in a drill hole in a rock 3 by 3 feet by 1½ feet high. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock 3 by 3 feet by 6 inches high at the edge of a young apple orchard inland from the station. Reference mark No. 2 is a like mark cut in a rock 3 by 4 feet by 1½ feet high northwest of the station and just outside of the orchard.
(Lat. 44-49-43.727 X. 247,373.10)
(Long. 75-18-25.305 Y. 1,761,242.42)

I.B.C. 44. - At Rockway Point. It is an International Boundary Commission Reference Monument.
(Lat. 44-49-41.259 X. 249,427.00)
(Long. 75-17-56.764 Y. 1,760,967.97)

U.S.L.S. Sharps (1872). - Is located about 5-1/2 miles above Waddington, N.Y. and about 1/4 mile S.E. of the river. It is in a level field about 455 feet S.E. of the river road, about 30 feet W. of a rail fence, and about 103 feet S.S.E. of the intersection of the rail and an old stone fence. It is 35.0 feet S.S. W. of a 3/4 inch drill hole at the point of an arrow cut in a 2 by 2 by 1 foot high boulder in the rail fence line; and 99.4 feet S.E. of a 3/4 inch drill hole at the point of an arrow cut in a 1-1/2 by 1-1/2 by 1/2 foot high boulder in an old stone fence line and brush strip. The elevation above the river is about 40 feet. The station mark, established in 1872, is a 1/6 inch drill hole which is about 3/4 of an inch from a 1 inch drill hole in the same stone about 4 feet below the ground surface. The surface mark is a 1 inch triangular drill hole in a stone 5 inches square, set about 1 foot below the ground surface.
(Lat. X. 250,537.07)
(Long. Y. 1,757,507.57)

I.W.C. 118. - On the south shore of the St. Lawrence River, opposite Iroquois Point, on the last sharp point of the southern shore line before the river turns north through the narrow channel. The station is 14 meters southwest of the brink of the high bank of the river on the northeast side of the point and 42 meters from the brink of the high bank at the extreme tip of the point. It is 3 meters northeast of a fence running in a southeasterly direction from the point. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a mass of concrete poured around some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a pointed rock 3 by 2 feet by 2 feet high just below the top of the high bank of the river and 15 meters east of the boat house on the northeast side of the point. Reference mark No. 2 is a like mark cut in a large rock showing a surface 1 foot in diameter and 6 inches high 1 meter northeast of the fence.
(Lat. 44-49-11.965 X. 248,213.52)
(Long. 75-18-13.112 Y. 1,758,015.29)

I.W.C. 121-sub. - About $1\frac{1}{2}$ miles southwest of Iroquois, on the dyke of the Galop Canal between the canal and the St. Lawrence River, about 125 meters west of where the dyke leaves the land on Iroquois Point. The station is at the top of the high bank on the river side of the dyke. It is an International Boundary Commission standard bronze-disk station mark set flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock showing 1 by $1\frac{1}{2}$ feet nearly flush with the ground east of the station and

one foot below the top of the high bank on the river side of the dyke. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 1½ feet by 1½ feet high about half way down the slope of the bank to the river. The directions and
(Lat. 44-49-18.459 X. 243,011.76)
(Long. 75-19-25.387 Y. 1,758,735.74)

I.B.C. 45. - On Toussaints Island. It is an International Boundary Commission Reference Monument.
(Lat. 44-48-29.691 X. 240,477.23)
(LOng. 75-19-59.709 Y. 1,753,827.20)

I.B.C. 46. - On Galop Canal dike just west of Presqu'ile. It is an International Boundary Commission Reference Monument.
(Lat. 44-48-40.065 X. 236,786.27)
(Long. 75-20-51.086 Y. 1,754,923.77)

I.W.C. 125. - About 1-1/4 miles northeast of Cardinal, on the dyke of the Galop Canal between the canal and the St. Lawrence River, 55 meters east of where the dyke widens west of the station, 7 meters from the canal, 9 meters from the river. It is a bronze plug with a center drill hole set 5 inches underground in the top of a solid concrete post 12 inches square and of unknown depth. A flat surface stone marked with a cross was found placed over the station mark; it was replaced. Reference mark No. 1 is an International Boundary Commission standard bronze-disk station mark with an arrow pointing toward the station cut on it and set flush with the ground in the top of a cylinder of concrete 7 inches in diameter and 26 inches in depth. Reference mark No. 2 is a drill hole cut in a rock at the edge of the high bank on the river side of the dyke.
(Lat. 44-48-05.779 X. 233,544.64)
(Long. 75-21-35.443 Y. 1,751,491.68)

I.B.C. 47. - On Lotus Island. It is an International Boundary Commission Monument.
(Lat. 44-47-07.318 X. 231,251.25)
(Long. 75-22-06.204 Y. 1,745,599.41)

I.W.C. 130. - On the south side of the St. Lawrence River directly opposite the town of Cardinal, Ontario; on a rise of ground between the "river-road" from Ogdensburg to Waddington and the river. The station is 3 meters west of the north corner of a rectangle outlined by large stones evidently used in years past as the foundation of a building. It is 30 meters north of the north fence of the highway.
It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in the rock, 2-1/2 by 3 feet in area, at the north corner of the rectangle of rocks. Reference mark No. 2 is a like mark cut in the rock, 2 by 3 feet by 1 foot high, at the west corner of the rectangle of rocks.
(Lat. 44-46-31.839 X. 232,763.47)
(Long. 75-21-44.607 Y. 1,741,986.56)

I.B.C. 48. - On Galop Canal bank just west of Cardinal. It is an International Boundary Reference Monument.
(Lat. 44-46-51.838 X. 225,134.94)
(Long. 75-23-30.724 Y. 1,744,110.22)

I.W.C. 129-sub. - About 1-1/2 miles west of Cardinal, on the north bank of the St. Lawrence River, on the most southern bend of the shore line north of Galop Rapids, about 150 meters west of the west end of the concrete approaches to the upper locks in the Galop Canal. The station is on canal property now leased by a coal company. It is 17 meters east of the line of the east face of the coal company's building, on top of and at the edge of the 25-foot high bank extending along the north side of the canal property, and 4 meters south of the north line fence of the canal property. It is an International Boundary Commission standard bronze disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches indepth. The subsurface mark is a brass screw set in a mass of concrete poured between some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 2-1/2 feet by 1 foot high one meter north of the line fence and at south end of a long line of rocks extending northward. Reference mark No. 2 is a similar mark cut in a large rock showing a surface 2-1/2 by 2 feet flush with the ground in the line of the canal property fence. Reference mark No. 3 is a like mark cut in a rock showing 2 by 2-1/2 feet by 6 inches high one-half meter north of the line fence and north of the station.
(Lat. 44-46-37.973 X. 221,724.04)
(Long. 75-24-17.758 Y. 1,742,750.45)

I.W.C. 132 = Red Mill-U.S.L.S. - On the south side of the St. Lawrence River about 6 miles below Ogdensburg, about 3/4 miles above Red Mills, about 200 meters from the river, and about 120 meters northwest of the "River road". The station is 4 meters south of a stone wall about 4 feet high and 4 feet wide on top. It is 55 meters east-northeast of a gate in the stone wall and 35 meters southwest of another gate in the wall. It is a drill hole within a triangle cut in a stone block 4 inches square and about 15 inches in depth placed with its top flush with the ground. The subsurface mark is a drill hole within a triangle cut in a irregular shaped granite boulder 14 inches in diameter placed 20 inches underground. Reference mark No. 1 is an International Boundary Commission standard bronze-disk station mark stamped "1" and set in the verticle face of a 5 by 5 foot black-banded boulder in the wall. Reference mark No. 2 is a like bronze-disk stamped "2" and set in the verticle face of a 5 by 5 foot boulder in the wall.
(Lat. 44-45-13.105 X. 223,088.00)
(Long. 75-23-57.286 Y. 1,734,136.46)

I.W.C. 131-sub. - On the north bank of the St. Lawrence River, 3-1/4 miles west of Cardinal, at the lower end of the "North Channel", opposite the north point of Duck Island. The station is about midway between Ontario Highway No. 2 and the River, and is 4 meters northeast of the fence along the northeast side of a cemetery lying between the highway and the river. It is an International Boundary Commission standard bronze-disk station

mark set in a drill hole in the top of a large embedded boulder showing a surface of 2 by 3 feet flush with the ground. There is no subsurface mark. Reference mark No. 1 is a drill hole and an arrow head pointing toward the station cut in a rock showing a 1 by 1 foot surface flush with the ground 1 meter northeast of the cemetery fence and southeast of the station. Reference mark No. 2 is a similar mark on a embedded boulder showing 1-1/2 by 2-1/2 feet by 6 inches high just northeast of the cemetery fence and northwest of the station.
(Lat. 44-45-46.176 X. 214,114.33)
(Long. 75-26-02.266 Y. 1,737,605.59)

I.B.C. 52. - On river bank midway between Prescott and Johnstown. It is an International Boundary Commission Reference Monument.
(Lat. 44-43-28.135 X. 201,731.83)
(Long. 75-28-51.150 Y. 1,723,794.53)

I.W.C. 135-sub. - On the north bank of the St. Lawrence River about 1½ miles below Prescott, about 140 meters north of Windmill Point lighthouse, about 90 meters south of Ontario Highway No. 2. The station is in a rocky pasture, 2 meters west of the southwest bank of an old stone quarry, about 75 meters northeast of an old stone house with attached barn, and about 120 meters southwest of an old stone barn with a wooden shed attached. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set with cement in a drill hole in a rock 30 inches underground.
(Lat. 44-43-19.365 X. 199,608.37)
(Long. 75-29-20.386 Y. 1,722,936.27)

I.W.C. 137. - Just east of Prescott, on the embankment around Fort Wellington, about 14 meters north of the southeast corner of the embankment. It is an International Boundary Commission standard bronze-disk station mark set 2 inches below the surface of the lawn in the top of a cylinder of concrete 8 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in a circular block of concrete 8 inches in diameter and 12 inches in dpeth placed 24 inches underground. There is but 1 reference mark, the center of an iron post about 3 inches in diameter and 24 inches high that was the center post of a revolving gun which is now replaced by a large old cannon on a 4-wheeled truck. The station is about the middle of the crest of the embankment, 1.15 meters from the nearest edge of the plank cap on the top of the piling revetment on the inside of the embankment, and 20.20 meters from the iron post used for a witness. The angle at the station between Station Ferry and the iron post is 8° 42'.
(Lat. 44-42-47.487 X. 194,520.16)
(Long. 75-30-30.215 Y. 1,719,780.09)

b. Horizontal Control Monuments at Proposed Site of Seaway, N. Y.

Station	Location	Transverse Mercator Coordinates	Remarks	Note Book File No.
Sta. 0 + 00	Centerline Main St.	X 364,866.89 Y 1,805,453.57	3/4" Iron pin buried in ℄ Road. to Sta. 25 + 19.04, 248° 00' 20" - 2,519.04'	MV-N-513/1
Sta. 25 + 19.04	Intersection Main Street and Horton Road	X 367,202.56 Y 1,806,397.09	3/4" Iron pin buried in ℄ Road. to Sta. 34 + 04.12, 248° 00' 20" - 885.08'	"
Sta. 34 + 04.12	Centerline Main Street	X 368.023.22 Y1,806,728.58	3/4" Iron pin buried in ℄ Road. To Sta. 46 + 17.32, 248° 00' 20" - 1213/ 20'	"
Sta. 46 + 17.32	" " "	X 369,148.11 Y 1,807,182.97	3/4" Iron pin buried in ℄ Road. To Sta. 56 + 46.16, 248° 00' 20" - 1028.84'	"
Sta. 56 + 46.16	" " "	X 370,102.07 Y 1,807,568.31	3/4" Iron pin buried in ℄ Road. To Sta. 58 + 24.88, 248° 00' 20",- 178.72'.	"
Sta. 58 + 24.88	" " "	X 370,267.93 Y 1,807,635.25	3/4" Iron pin buried in ℄ Road.	"
Sta. 5 + 74.00	Intersection Horton Road & St. Lawrence Ave.	X 366,888.03 Y 1,806,877.24	3/4" Iron pin buried in ℄ Road. To Sta. 9 + 74.00, 146° 46' 20"- 400.00'	"
Sta. 9 + 74.00	Intersection Horton Road and St. Regis Ave.	X 366,668.84 Y 1,807,211.84	3/4" Iron pin buried in ℄ Road. To Sta. 15 + 01.24, 146° 46' 20" 527.24'	"

Station	Location	Transverse Mercator Coordinates	Remarks	Note Book File No.
Sta. 15 + 01.24	Intersection Horton Road and Summit Avenue	X 366,379.76 Y 1,807,652.53	3/4" Iron pin buried in ℄ Road. To Sta. 24 + 46.08. 146° 46' 20". 944.84'	MV-N-513/1
Sta. 24 + 46.08	Intersection Horton Road and Hillcrest Road	X 365,861.90 Y 1,808,442.68	3/4" Iron pin buried in ℄ Road.	"
	Intersection Hillcrest Road and 8th Ave.	X 367,694.79 Y 1,808,548.01	3/4" Iron pin.	"
	Intersection Hillcrest Road and 4th Ave.	X 368,777.98 Y 1,808,651.21	3/4" Iron pin.	"
	Intersection 4th St. & 3rd St.	X 369,160.01 Y 1,807,705.46	3/4" Iron pin.	"
	Intersection St. Lawrence Ave. and 11th St.	X 367,438.61 Y 1,807,099.64	3/4" Iron pin.	"
	Intersection St. Lawrence Ave. & 10th St.	X 367,670.42 Y 1,807,193.27	3/4" Iron pin	"
	Property line marker South of Main St.	X 365,171.68 Y 1,804,984.16	4" sq. stone monument	MLA-N-570/3
	" " "	X 370,452.52 Y 1,807,365.49	Stone Monument	"
	Intersection St. Lawrence Ave. and 12th St.	X 367,206.81 Y 1,807,006.00	3/4" Iron Pin	MV-N-513/1

c. Horizontal Control Monuments Along Proposed Long Sault Canal.

Station	Location		Transverse Mercator Coordinates	Remarks
49 + 58.48	Richards Point ¢	Long Sault Canal	X 335,793.12 Y 1,808,241.78	1" Iron pipe
57 + 54.00	"	"	X 336,568.95 Y 1,808,417.65	"
68 + 61.33	"	"	X 337,648.88 Y 1,808,662.46	"
194 + 71.25	Massena Point ¢	"	X 349,946.78 Y 1,811,450.27	"
205 + 86.03	"	"	X 351,033.97 Y 1,811,696.73	"
229 + 87.17	"	"	X 353,375.70 Y 1,812,227.58	"
233 + 31.20	"	"	X 353,711.22 Y 1,812,303.63	"
248 + 01.36	"	"	X 355,145.00 Y 1,812,628.66	"
268 + 53.60	"	"	X 357,146.46 Y 1,813,082.37	"

Station	Location	Transverse Mercator Coordinates	Remarks
280 + 99.90	Massena Point ℄ Long Sault Canal	X 358,361.92 Y 1,813,357.90	1 " Iron Pipe
288 + 25.35	" "	X 359,069.42 Y 1,813,518.29	"
300 + 84.24	" "	X 360,297.15 Y 1,813,796.60	"
320 + 00.00	" "	X 362,165.51 Y 1,814,220.14	"
335 + 20.20	" "	X 363,664.04 Y 1,814,475.91	"
349 + 22.56	" "	X 365,046.41 Y 1,814,711.86	"
352 + 80.00	" "	X 365,398.75 Y 1,814,772.00	"
363 + 73.48	" "	X 366,476.64 X 1,814,955.97	"
381 + 27.02	" "	X 368,205.19 Y 1,815,251.00	"
390 + 24.78	" "	X 369,090.15 Y 1,815,402.05	"
396 + 22.61	" "	X 369,679.46 Y 1,815,502.63	"
401 + 32.50	" "	X 370,182.08 Y 1,815,588.42	"
408 + 18.27	" "	X 370,858.07 Y 1,815,703.80	"

Station	Location	Transverse Mercator Coordinates	Remarks
413 + 80.00	Massena Point ℄ Long Sault Canal	X 371,411.79 Y 1,815,798.31	1" Iron pipe
425 + 86.58	" "	X 372,601.17 Y 1,816,001.32	"
432 + 52.65	" "	X 373,257.75 Y 1,816,113.38	"
452 + 09.22	" "	X 375,186.43 Y 1,816,442.57	"
460 + 17.41	" "	X 375,983.10 Y 1,816,578.55	"
475 + 78.29	" "	X 377,521.73 Y 1,816,841.16	"
494 + 64.71	" "	X 379,381.25 Y 1,817,158.55	"
504 + 45.32	" "	X 380,347.88 Y 1,817,323.54	"
516 + 41.04	" "	X 381,526.56 Y 1,817,524.71	"
522 + 18.97	" "	X 382,096.25 Y 1,817,621.95	"
532 + 66.99	" "	X 383,129.33 Y 1,817,798.28	"
541 + 89.00	" "	X 384,038.20 Y 1,817,953.41	"

Station	Location	Transverse Mercator Coordinates	Remarks
545 + 34.04	Massena Point ℄ Long Sault Canal	X 384,378.32 Y 1,818,011.46	1" Iron pipe
551 + 92.45	" "	X 385,027.34 Y 1,818,122.23	"

d. Horizontal Control Monuments at Proposed Long Sault Dam.

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Note Book File No.
I.B.C. 15 ecc.	West end Barnhart Island	X 363,721.97 Y 1,823,307.88	U.S.E.O. pipe and bronze cap.	BD-1-500/1	BD-N-500/1
LSD 6	On Long Sault Dam Base Line West end Barnhart Island.	X 363,422.73 Y 1,822,198.51	U.S.E.O. pipe and bronze cap.	"	"
Ross B-31	West End Barnhart Island	X 364,120.35 Y 1,821,384.69	Concrete monument	"	"
LSD 1	Mainland at Long Sault Dam Site	X 363,305.84 Y 1,819,905.00	U.S.E.O. pipe and bronze cap.	"	"
LSD 2	" "	X 362,868.73 Y 1,819,921.32	" " " "	"	"
Ross B-36	" "	X 362,327.05 Y 1,819,451.91	Concrete monument.	"	"
LSD 3	East end Long Sault Island	X 361,520.14 Y 1,820,089.07	U.S.E.O. pipe and bronze cap.	"	"
LSD 4	" " " "	X 362,196.29 Y 1,820,983.40	" " " "	"	"

e. Horizontal Control Monuments at Proposed Point Rockway Canal.

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Field Book File No.
Q 6	Station 100+06.04 on ℄ of Rockway Point Canal	X 250,224.57 Y 1,760,245.14	U.S.E.D.Bronze Cap & Pipe	QS-1-511/8	SLA-N-570/18
Q 7	Rockway Point Canal	X 250,963.16 Y 1,761,225.86	U.S.E.D.Bronze Cap & Pipe to Q 8 327°51'15" 447.02'	QS-1-511/7	"
Q 8	Station 111+53.26 on ℄ Rockway Point Canal	X 251,201.01 Y 1,760,847.37	1" Iron Pipe	QS-1-511/8	"
Q 9	Rockway Point Canal	X 251,488.73 Y 1,760,434.28	U.S.E.D.Bronze Cap & Pipe to Q 8 145°10'45" 503.41'	"	"
Q 10	" " "	X 251,784.89 Y 1,759,984.75	1" Iron Pipe	"	"
Q 11	Station 120+61.80 on ℄ Rockway Point Canal	X 251,973.92 Y 1,761,324.09	1" Iron Pipe	QS-1-511/7	"
Q 12	Rockway Point Canal	X 252,418.05 Y 1,762,297.63	U.S.E.D. Bronze Cap & Pipe to Q 13 148°39'00" 595.44'	"	"
Q 13	Station 129+48.17 on ℄ Rockway Point Canal	X 252,727.95 Y 1,761,789.19	2"x2" hub	"	"
Q 14	Rockway Point Canal	X 252,924.16 Y 1,761,519.96	U.S.E.D. Bronze Cap & Pipe to Q 13 143°55'00" 333.14'	"	"
Q 15	" " "	X 253,253.82 Y 1,761,012.00	1" Iron Pipe to Q 14 147°01'00" 605.56'	"	"
Q 16	Station 138+60.68 on ℄ Rockway Point Canal	X 253,504.22 Y 1,762,269.24	1" Iron pipe	"	"

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Field Book File No.
Q 17	Station 147+30.73 on ℄ Rockway Point Canal	X 254,244.38 Y 1,762,724.52	1" Iron Pipe	QS-1-511/7	SLA-N-570/18
Q 18	Station 156+99.17 on ℄ Rockway Point Canal	X 255,068.23 Y 1,763,232.67	1" Iron Pipe	"	"
Q 19 = Angle Point	Station 166+35.73 on ℄ Rockway Point Canal	X 255,865.89 Y 1,763,724.66	U.S.E.D.Bronze Cap & Pipe	"	"
Q 21	Station 171+22.43 on ℄ Rockway Point Canal	X 256,096.94 Y 1,764,153.02	1" Iron pipe	"	"
Q 22	Station 176+29.91 on ℄ Rockway Point Canal	X 256,337.86 Y 1,764,599.67	1" Iron Pipe	"	"
Q 22A	Station 181+89.99 on ℄ Rockway Point Canal	X 256,603.75 Y 1,765,092.61	"	"	"
Q 23	Rockway Point Canal	X 256,611.83 Y 1,766,723.22	1" Iron Pipe to Q 24 327°41'30" 879.60'	"	"
Q 24	Station 190+96.77 on ℄ Rockway Point Canal	X 257,081.96 Y 1,765,979.20	1" Iron Pipe	"	"
Q 25	Rockway Point Canal	X 257,395.20 Y 1,765,484.52	1" Iron Pipe to Q 24 147°41'30" 586.02'	"	"
Q 27	Station 200 + 58.95 on ℄ Rockway Point Canal	X 257,543.48 Y 1,766,834.85	U.S.E.D.Bronze Cap & Pipe	"	"
Q 28	Rockway Point Canal	X 257,987.53 Y 1,768,344.65	1" Iron Pipe to Q 29 328°17'50" 376.18	"	"
Q 29	Station 214+10.74 on ℄ Rockway Point Canal	X 258,185.22 Y 1,768,024.60	U.S.E.D. Bronze Cap & Pipe	"	"

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Field Book File No.
Q 30	Rockway Point Canal	X 258,488.77 Y 1,767,523.87	1" Iron Pipe to Q 29 148°46'30" 585.55'	QS-1-511/7	SLA-N-570/18
Q 31	" " "	X 258,767.24 Y 1,767,080.10	1" Iron Pipe to Q 30 147°53'30" 523.91'	"	"
Q 32	Station 231+97.00 on ℄ Rockway Point Canal	X 258,980.79 Y 1,769,496.96	1" Iron Pipe	"	"

F. Horizontal Control Monuments for Determining Property Lines.

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Field Book File No.
G 1	Just East of Chimney Point	X 217,414.46 Y 1,727,251.28	U.S.E.D. Bronze Cap & Pipe to G2 221°05'40" 1272.10'	GS-1-511/2	SLA-N-570/18
G 2	" "	X 218,250.62 Y 1,728,209.97	To G3 220°17'20" 856.60'	"	"
G 3	" "	X 218,804.53 Y 1,728,863.38		"	"
G 4	South of Galop Island	X 224,645.90 Y 1,733,533.70	To G5 234°39'50" 1754.57'	"	"
G 5	" "	X 226,077.22 Y 1,734,548.49	To G6 231°19'10" 825.38'	"	"
G 6	" "	X 226,721.55 Y 1,735,064.34		"	"
G 7	" "	X 230,789.20 Y 1,738,859.60	To G8 227°02'00" 744.55'	GS-1-511/5	"
G 8	" "	X 231,334.03 Y 1,739,367.06	To G9 219°00'00" 820.59'	"	"
G 9		X 231,850.14 Y 1,740,004.78		"	"
Q 1	Sparrowhawk Point	X 234,871.82 Y 1,747,313.56	To Q2 237°38'00" 1258.73'	GS-1-511/4	"
Q2	" "	X 235,934.75 Y 1,747,986.67	To IWC 124 Sub 196°26'02" 975.78'	"	"
IWC 124	Sub Sparrowhawk Point	X 236,210.92 Y 1,748,922.15	IBC Bronze disk	"	"
Q3	Along River Road East of Toussaints Island	X 244,635.99 Y 1,752,464.62	To Q4 209°32'20" 1096.53'	"	"
Q4	" "	X 245,176.95 Y 1,753,417.64	To Q5 197°38'50" 766.08'	"	"
Q5	" "	X 245,409.44 Y 1,754,146.90		"	"

Station	Location	Transverse Mercator Coordinates	Remarks	Map File No.	Field Book File No.
W 1	Along River Road at Leishmans Point	X 261,079.05 Y 1,767,949.17	U.S.E.D. Bronze Cap & Pipe to W2 245°03'20" 1433.22'	QS-1-511/7	SLA-1-570/18
W 2	" "	X 262,378.58 Y 1,768,553.62	U.S.E.D. Bronze Cap & Pipe to W 3 224°03'20" 928.17'	"	"
W 3	" "	X 263,023.99 Y 1,769,220.67	U.S.E.D. Bronze Cap & Pipe	"	"
W 4	Along River Road about 1 mile East of Waddington	X 268,215.82 Y 1,771,360.09	U.S.E.D. Bronze Cap & Pipe to W 5 239°38'30" 841.80'	WS-1-511/10	"
W 5	" "	X 268,942.21 Y 1,771,785.53	U.S.E.D. Bronze Cap & Pipe to W 6 250°44'50" 1099.06'	"	
W 6	" "	X 269,979.80 Y 1,772,147.94	U.S.E.D. Bronze Cap & Pipe	"	"

2. Following are descriptions and elevations of all vertical control benchmarks that were used on this survey. All are based on Mean Sea Level Datum, 4th General Adjustment 1912. Descriptions of the International Waterways Commission Monuments were taken from Mr. Hefty's Report noted in Chapter II of the main report. Descriptions of the U.S. Deep Waterway bench marks were taken from lists obtained from the U.S. Lake Survey noted in Chapter II of the main report. The International Boundary Commission Reference Monuments are concrete monuments as shown on the attached photograph. Canadian benchmark descriptions were taken from publication No. 57 noted in Chapter II of the main report.

a. Description of Vertical Control Bench Marks in the United States.

I.B.C. MOTT. - In the St. Regis Indian Reservation, on the south bank of the St. Lawrence River about 1-1/4 miles east of the Rooseveltown-Cornwall International Bridge. It is on the farm of Angus Tarbell, at the north edge of a field, about 7 feet from the edge of the high bank of the river. It is about 70 feet east of a small gully, about 50 feet east of a fence and about 25 feet above the level of the set flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 30 inches in depth. The subsurface mark is a brass screw set in a circular block of concrete 30 inches underground. (Mon. set in 1938 by Mr. H. G. Hefty(Elev. 176.60 feet)

P.B.M. 2. - Is near the mouth of the Grass River, the top of a round headed brass bolt set into a concrete base on the north side of the Grass River Road, just east of the mouth of the Grass River. The bench is 3 feet south of the north fence line of the road and on the west fence line of house lot of William Tucker. The bench was set 1.2 feet underground and marked on the concrete base, U.S.P.B.M. 2." (Elev. 207.98 feet)

T.B.M. 552. - Massena Point, on the north bank of the Grass River just west of its junction with the St. Lawrence River. On the center line of the proposed Long Sault Canal at Station 551 + 92.45 about 52 feet east of a north and south fence line, it is the top of a 1" iron pipe, 6 feet in depth, set flush with the ground. (Elev. 183.38 feet)

T.B.M. 532. - Massena Point, on the center line of the proposed Long Sault Canal at Station 532 + 66.99 on the north bank of a dry run. It is the top of a 1" iron pipe 6 feet in length set about 1 foot above ground. (Elev. 184.22 feet)

T.B.M. M-201. - Massena Point, on the west side of Woods cross road, 75 feet south of Station 475 + 78 on the center line of the proposed Long Sault Canal. It is the head of a Railroad spike set in the base of an 18" elm tree. (Elev. 195.19 feet)

T.B.M. "Lord". - Massena Point, on northwest side of middle road along fence line on prolongation of road running northwest from Massena Center and making "T" intersection with middle road. It is 15 feet southeast of fence line and about 600 feet along the fence from Station 374 + 60 of the proposed Long Sault Canal. Head of Railroad spike set horizontally in 16 inch Elm. (Elev. 204.89 feet)

T.B.M. S-117. - Massena Point. On Horton Cross Road about one mile south of the River Road. In southwest corner of school yard. Head of railroad spike driven in root of 24 inch white ash. (Elev. 233.71 feet)

T.B.M. 320. - Massena Point. Station 320 + 00 on the proposed Long Sault Canal. This is the angle point in the canal. It is the top of a 1 inch iron pipe 6 feet in depth set flush with the ground. (Elev. 215.49 feet)

P.B.M. 3. - Is 2-1/4 miles west of Polly's Gut, the top of a round headed brass bolt set into a concrete base 3 feet south of fence on the north side of River Road, and in the center of the north and south road branching off the River Road opposite the farm of John Wood. The bench is 25 feet east of a honey locust hedge on the west line of said farm and is 1.3 feet under the surface of the ground. The concrete base is marked "U.S.P.B.M. 3." (Elev. 204.38 feet)

T.B.M. "A4". - Massena Point. On north side of River Road at Robinson Bay, 390 feet east of driveway to Cumming's farm. It is the head of a railroad spike driven into an electric pole #S.L.U.-121. (Elev. 191.04 feet)

P.B.M. 4. - Is opposite the head of Barnharts Island, the top of a round headed 1/4-inch brass bolt, set into a concrete base 14 feet underground and situated on the south side of the River Road, on line of a stone fence running north and south opposite the barnyard of Frank Polly's farm. The bench is 5.5 feet from the south fence of the road and 348 feet east of Polly's Creek, and is marked on the concrete base, "U.S.P.B.M. 4." (Elev. 221.38 feet)

T.B.M. 27. - Is opposite the foot of Long Sault Island, top of knob on a boulder situated 15 meters north of stone fence on north side of River Road, 100 meters east of house on south side of road, 125 meters east of house on north side of road and 475 meters west of Polly's Creek. (Elev. 274.88 feet)

T.B.M. 30. - Is 2-1/2 miles below head of Massena Canal, top of knob on southeast corner stone of foundation of Carton's brick residence, 2400 meters southwest from Polly's Creek on River Road. (Elev. 233.47 feet)

P.B.M. 5. - Is 1-1/2 miles below head of Massena Canal, the top of a round headed 1/4-inch brass bolt set into a concrete base 1.2 feet below the surface of the ground and situated on the north side of the River Road at the corner of the fence in the turn in the road at the house of Norman Hopson. The bench is 2.8 feet from the fence corner and is marked "U.S.P.B.M. 5." (Elev. 247.36 feet)

B.M. "High Bridge". - Bridge over Massena Power Canal on the River Road about 1/4 mile below the entrance to the Canal. It is the top of the northwest corner of the east abutment. (Elev. 270.15 feet)

B.M. "Pontoon". - Bridge over Massena Power Canal about 1-1/4 miles below the entrance to the canal. It is a cross cut in the top of the south concrete wingwall. (Elev. 216.39 feet)

B.M. "Alcoa". - Massena, combination railroad and highway bridge over Massena Power Canal at the Aluminum plant. It is a cross cut in the northeast corner of a 2 foot x 16 foot concrete slab at the north end of the bridge. (Elev. 219.92 feet)

B.M. "Bolt". - Highway bridge across Grass River at the Aluminum Plant at Massena. The northwest corner of the bridge. It is a cross cut in the top of the northeast bolt of the northwest corner of railing. (Elev. 207.33 feet)

B.M. "F4". - At crossing of middle road and the Aluminum Company Power line from Canada. Tower No. 386. It is the top of the north corner of the concrete base of the north leg of the tower. (Elev. 212.66 feet)

T.B.M. "Transformer". - At crossing of Horton road and Middle raod, 830 feet south of, along Horton road, and on the east side of the road. It is the head of a railroad spike 18 inches above ground in an electric pole holding a transformer. (Elev. 198.78 feet)

B.M. "S-108". - Massena Center, concrete highway bridge on Massena Center Road over Kinney Creek. It is a cross cut on southwest corner of the east abutment. (Elev. 191.12 feet)

I.W.C. 22. - On the most eastern end of Barnhart Island, on the first high ground west of the shore line. In the flat top of a conspicious lone rock about 6 x 8 feet in size and 5 feet high. It is an International Boundary Commission standard bronze-disk. (Elev. 182.07 feet)

I.B.C. 10. - On the east end of Barnhart Island. An International Boundary Commission reference monument. It is the top of the monument. (elev. 192.47 feet)

I.W.C. 36. - On Barnhart Island, about 900 meters east of the west end of the island and about 275 meters south of the north shore of the island. It is an International Boundary Commission standardbronze-disk station mark set nearly flush with the ground in the top of a large rock. The subsurface mark is a brass screw set in a drill hole in a rock 30 inches underground. Reference mark No. 1 is a drill hole and cross cut in the top of a conical rock projecting 6 inches above the surface of the ground in azimuth 128° 27', distant 4.288 meters from the station. Reference mark No. 2 is a drill hole and cross cut in the top of a rounded boulder, 2 feet across and 8 inches above the surface of the grouhd, under an elm tree with low and heavy twisted branches, and in azimuth 59° 15', distant 6.154 meters from the station. (Elev. 244.45 feet)

I.W.C. 38. - On Barnhart Island, about 150 meters from the west end of the island, on a point of the north shore-line just west of a slough and ravine. The station is about 15 meters back from the edge of the high bank of the river. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in a large rock. The subsurface mark is a brass screw set in a drill hole in a rock 30 inches underground. Reference mark No. 1 is a drill hole and cross cut on a rock 3 x 2½ feet in size by 1 foot high in azimuth 281° 48', distant 11.698 meters from the station. Reference mark No. 2 is a drill hole and cross cut on a rock 4 x 4 x 2 feet high in azimuth 326° 23', distant 26.393 meters from the station. (Elev. 224.33 feet)

I.B.C. 15. - On the west end of Barnhart Island. An International Boundary Commission Reference monument. It is the top of the monument. (Elev. 259.68 feet)

P.B.M. 6. - Is 1-1/4 miles above Massena Canal, the top of a round headed 1/4-inch brass bolt set into a concrete base 1.3 feet underground, 3 feet north of the south fence line of the River Road and 58.5 feet east of the east fence of Isaac Richard's residence at Richards Landing. The bench is marked on the concrete base, "U.S.P.B.M. 6". (Elev. 232.38 feet)

P.B.M. Louisville Landing. - Is at Louisville Landing, N. Y., the center punch mark of a 1/4-inch brass bolt cemented into the west face of the hotel of R. B. Mathews at Louisville Landing; 2.6 feet from the northwest corner of the building, in a foundation stone, .9 feet above the ground, marked "U. S." (Elev. 230.01 feet)

P.B.M. 7. - Is 2-1/4 miles above Louisville Landing, N. Y., the top of a round headed 1/4-inch brass bolt set into a concrete base 1.4 feet underground and situated on the north side of the River Road, 22.7 feet west and on west fence line of Charles Whalen's house. The bench is 3 feet east of said Whalen fence and on the fence line of the River Road and is marked "U. S. P. B. M. 7." (Elev. 224.21 feet)

P.B.M. 9. - Is about 600 meters northeast of the bridge across Coles Creek near its mouth; it is the top of a round headed 1/4-inch brass bolt set into a concrete base 1.2 feet below the ground, on the north side of the River Road abreast of Egg Island (or Ruthefords or Carrs Island) in Coles Creek. The bench is nearly on said north road line and 5.8 feet south of the south corner of a large wooden barn of William Hosmer and on the concrete base is marked "U.S.P.B.M. 9." (Elev. 238.83 feet)

P.B.M. 10. - Is 2½ miles below Waddington, N. Y.; it is the top of a round headed 1/4-inch brass bolt set into a concrete base covered by 1.2 feet of earth and situated on the north side of the river road, 18.5 feet south of a fence corner and on the property line between Scott and Dartis lots, 22.2 feet southeast of a 30 inch elm tree, 72.5 feet northeast of a chisel mark on northeast corner of culvert headwall and opposite a two-story green frame house on south side of highway No. 37. The concrete base is marked "U.S. P.B.M. 10." U.S. Deep Waterway B. M., 1898. (Elev. 236.26 feet)

P.B.M. "B". - Is at Waddington, N. Y., is the center punch mark on a 1/4 inch brass bolt cemented into the foundation masonry on the northeast face, 1.9 feet from the north corner and 0.8 feet above the ground on the town hall. Bench mark is marked "U.S.B." (Elev. 276.06 feet)

U.S.L.S. "W2". - On the south side of Ogden Island at the highway entrance. It is a standard U. S. Lake Survey Bronze-disk set in top of large boulder at fence corner on east side of road. (Elev. 233.49 feet)

P.B.M. 11. - Is at Waddington, N. Y., is the center punch mark on a 1/4 inch brass bolt cemented into the upper foundation stone, 3 inches from the south corner and 24 inches above the ground, on the southwest face of St. Pauls Episcopal Church; the letters "U. S. 11." are cut into the stone. (Elev. 278.40 feet)

I.B.C. 38. - On Ogden Island. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 239.95 feet)

I.W.C. 106. - On the western end of Ogden Island in the St. Lawrence River, about 450 meters from the extreme west end of the island and 100 meters south of the north shore of the island. The station is in open pasture land, in azimuth 310° 13', 90.5 meters distant from Boundary Reference Monument No. 39. There is a row of trees about 120 meters south of the station, and a red cottage is to be seen about 200 meters to the east of the station. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock showing 4 by 5 feet 18 inches high above ground to the northeast of the station. Reference mark No. 2 is a like mark cut on a rock of about the same size to the northwest of the station. (Elev. 246.74 feet)

T.B.M. 70. - Is 2-1/4 miles above Waddington, N. Y., being top of spike in root of a 30-inch pine situated on the south side of the River Road, 80 meters southeast from the residence of Luther Marshall. (Elev. 251.02 fee

I.W.C. 108. - About 2 miles west of Waddington, about 400 meters upstream from the extreme tip of Leishman Point on the south shore of the St. Lawrence River. The station is about 23 meters back from the shore of the river and 90 meters northwest of an old house. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 2 feet by 1½ feet high 8 meters back from the edge of the high bank of the river. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a rock 4 by 5 feet by 2 feet high on slightly higher ground about 60 meters back from the edge of the high bank of the river. (Elev. 238.87 feet)

P.B.M. 12. - Is 3-1/2 miles above Waddington, N. Y., being the top of a round headed 1/4-inch brass bolt cemented into the top of a large granite boulder on the south side of the River Road at the turn just west of Point Three Points (Better known as White House or Waddell's Point); the boulder forms the end of a stone wall near the entrance to the property of Waddell and is marked "U.S.P.B.M. 12." (Elev. 253.30 feet)

I.B.C. 44. - At Rockway Point. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 241.74 feet)

U.S.L.S. SHARPS (1872). - Is located about 5-1/2 miles above Waddington, N. Y. and about 1/4 mile S.E. of the river. It is in a level field about 455 feet S.E. of the river road, about 30 feet W. of a rail fence, and about 103 feet S.S.E. of the intersection of the rail and an old stone fence. It is 35.0 feet S.S.W. of a 3/4 inch drill hole at the point of an arrow cut in a 2 by 2 by 1 foot high boulder in the rail fence line; and 99.4 feet S.E. of a 3/4 inch drill hole at the point of an arrow cut in a 1-1/2 by 1-1/2 by 1/2 foot high boulder in an old stone fence line and brush strip. The elevation above the river is about 40 feet. The station mark, established in 1872, is a 1/6 inch drill hole which is about 3/4 of an inch from a 1 inch drill hole in the same stone about 4 feet below the ground surface. The surface mark is a 1 inch triangular drill hole in a stone 5 inches square, set about 1 foot below the ground surface. (Elev. 285.11 feet)

P.B.M. 13. - Is at Tilden Post Office, N. Y., is the center punch mark in a 1/4-inch brass bolt cemented into foundation stone of Tilden Post Office situated on the north side of the River Road on the town line between Lisbon and Waddington, N. Y. The mark is on the southeast face of the building, 7.2 feet from the south corner and 0.8 feet above the ground. The letters "U. S." are cut into the stone. (Elev. 269.95 feet)

I.W.C. 118. - On the south shore of the St. Lawrence River, opposite Iroquois Point, on the last sharp point of the southern shore line before the river turns north through the narrow channel. The station is 14 meters southwest of the brink of the high bank of the river on the northeast side of the point and 42 meters from the brink of the high bank at the extreme tip of the point. It is 3 meters northeast of a fence running in a southeasterly direction from the point. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a mass of concrete poured around some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a pointed rock 3 by 2 feet by 2 feet high just below the top of the high bank of the river and 15 meters east of the boat house on the northeast side of the point. Reference mark No. 2 is a like mark cut in a large rock showing a surface 1 foot in diameter and 6 inches high 1 meter northeast of the fence. (Elev. 242.26 feet)

P.B.M. 14. - Is 1 mile above Boice Post Office, N. Y., being the top of a round headed 1/4-inch brass bolt set into a concrete base, covered by 1 foot of earth, on the north side of the River Road at the bend in the road,

on the east property line of Silas Samon's Property. The bench is 7 feet west from a large sugar maple tree blazed and marked "U. S." The concrete base is marked "U.S.P.B.M. 14." (Elev. 273.52 feet)

I.B.C. 47. - On Lotus Island. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 246.05 feet)

I.W.C. 130. - On the south side of the St. Lawrence River directly opposite the town of Cardinal, Ontario; on a rise of ground between the "river-road" from Ogdensburg to Waddington and the river. The station is 3 meters west of the north corner of a rectangle outlined by large stones evidently used in years past as the foundation of a building. It is 30 meters north of the north fence of the highway. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in the rock, 2-1/2 by 3 feet in area, at the north corner of the rectangle of rocks. Reference mark No. 2 is a like mark cut in the rock, 2 by 3 feet by 1 foot high, at the west corner of the rectangle of rocks. (Elev. 293.28 feet)

I.B.C. North Galop. - On the Galop Island, about 400 feet south of the extreme north end of the northeast point of Galop Island. It is an International Boundary Commission standard bronze-disk set in a boulder flush with the ground. Reference arrows are cut into two nearby flat rocks. (Elev. 248.81 feet)

P.B.M. 15. - Is 7 miles below Ogdensburg, N. Y., being center punch mark in in a 1/4-inch brass bolt cemented into the corner stone on the west corner of the Episcopal stone church at Lisbon Post Office. The church is on the south side of the River Road. The bench is on the north face of the church, 10 inches from the west corner, 28 inches above the ground and is marked "U.S. 15." (Elev. 278.72 feet)

I.W.C. 132 = Red Mill-U.S.L.S. - On the south side of the St. Lawrence River about 6 miles below Ogdensburg, about 3/4 miles above Red Mills, about 200 meters from the river, and about 120 meters northwest of the "river road". The station is 4 meters south of a stone wall about 4 feet high and 4 feet wide on top. It is 55 meters east-northeast of a gate in the stone wall and 35 meters southwest of another gate in the wall. It is a drill hole within a triangle cut in a stone block 4 inches square and about 15 inches in depth placed with its top flush with the ground. The subsurface mark is a drill hole within a triangle cut in a irregular shaped granite boulder 14 inches in diameter placed 20 inches underground Reference mark No. 1 is an International Boundary Commission standard bronze-disk station mark stamped "1" and set in the verticle face of a 5 by 5 foot black-banded boulder in the wall. Reference mark No. 2 is a like bronze-disk stamped "2" and set in the verticle face of a 5 by 5 foo boulder in the wall. (Elev. 310.27 feet)

T.B.M. 87 - Is 1400 meters above Lisbon Post Office, N. Y., being top of a knob on a boulder 4 feet by 3 feet by 3 feet situated on the north side of the River Road, 50 meters east from the residence of Aldan Dawson and 40 meters below the 6th mile post northeast from Ogdesnburg. (Elev. 307.65 feet)

P.M.B. 16 - Is 3 miles below Ogdensburg, N. Y., being the center punch mark in a 1/4-inch brass bolt cemented into red sandstone coping on the north side of the infirmary building in the New York State Hospital grounds, below Ogdensburg, N. Y. The mark is 12.7 feet from the west corner of said building and 50.5 feet from center of doorway on the north side, and is 4 feet above the ground. The letters "U.S." are cut into the coping above the mark. (Elev. 282.23 feet)

b. Description of Vertical Control Bench Marks in Canada.

B.M. MCMLXXIII. - Cornwall; New York Central Railroad bridge over north channel of St. Lawrence river, between Canadian main shore and Cornwall island. North concrete abutment, west face of top stone of coping at west side of track. Bolt set horizontally. (Elev. 224.25 feet)

I.B.C. II. - On Cornwall Canal Dike, just below Lock 20. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 200.47 feet)

B.M. MCMLXIX. - Stone retaining wall at south side of Lock 20, Cornwall canal, 1-1/4 miles southeast of Mille Roches. Bolt set horizontally in south face, 7 inches below top, of the southerly one of the two blocks of stone whose east ends are semicircular, 30 feet east of heel of lower gate. (Elev. 203.61 feet)

B.M. MCMLXXI. - Swing highway bridge over Cornwall canal in Mille Roches. East face of south abutment, bolt set horizontally at centre of first block of stone above coping of canal retaining wall. (Elev. 206.24 feet)

B.M. MCMLXXXV. - In Ault park, Sheek island, in large boulder bearing tablet in memory of Simon William Ault and Caroline Brownell Ault, on top of bank above Long Sault rapids. Bolt set horizontally in highest vertical face, 20 inches above ground. (Elev. 225.33 feet)

I.B.C. 16. - On west end of Sheek Island. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 206.94 feet)

I.B.C. 17. - On Cornwall Canal Dike at head of Long Sault Rapids. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 207.62 feet)

B.M. MCMLXXXIV. - International Boundary Commission's concrete reference monument No. 17, on strip of land between Cornwall canal and Long Sault rapids, opposite a point 1-1/2 miles east of main corners. Bolt set horizontally, facing north. (Elev. 206.40 feet)

B.M. MCMLXXX. - Lock 21; Stone retaining wall at south side of lower entrance to Lock 21, Cornwall canal, 3/4 mile east of main corners. Bolt set horizontally in east end of north face of wall, in top course of stonework 125 feet east of heel of gate. (Elev. 204.77 feet)

I.W.C. 91-sub. - At lock 23 at the lower end of the Morrisburg canal, on the embankment between the old or unused lock and the lock now in use. It is 28 meters west of the east end of the embankment between the two locks, 3-1/2 meters south of the concrete wall on the south side of the north or old lock, 8 meters north of the steps leading down from the north wall of the south or used lock, and 3 meters west of the first cast-iron snubbing post appertaining to the north lock. It is a standard International Boundary Commission bronze-disk station mark set flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in a mass of concrete attached to a large rock, 24 inches underground. Reference mark No. 1 is the southeastern corner of the concrete wall and walk at the head of the stairs leading down from the north or unused lock. Reference mark No. 2 is the northwest corner of the concrete walk at the head of the stairs leading down from the north wall of the south or used lock. Reference mark No. 3 is the center of the first cast-iron snubbing post on the high level on the north side of the south or used lock. (Elev. 227.44 feet)

B.M. MMLX. - Morrisburg; Curved stone wall at south side of lower entrance to old lock 23, Morrisburg canal. Bolt set horizontally facing east, in second course of stonework above floor of mooring pier, 4 feet south of north edge of same. (Elev. 219.32 feet)

B.M. MMLVIII. - Morrisburg; Stone wall along south bank of Morrisburg canal, at point where wall ends and rip-rap begins, opposite the foot of Stafford street. Bolt set vertically in coping of wall, 18 inches from west end, 2 feet 2 inches from north edge and 110 feet west of a concrete block power house. (Elev. 229.13 feet)

I.W.C. 95. - About 3/4 mile west of Morrisburg, on the dyke of the Morrisburg canal between the canal and the river, 1-1/8 miles above lock No. 23. The station is about the middle of the dyke and directly opposite the lower end of Ogden Island. It is an International Boundary Commission bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole in a rock showing 1-1/2 by 1-1/2 feet by 6 inches high above ground on the top of the bank on the river side of the dyke and on line from the station to the southern tangent of Canada Island. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a boulder 4 by 4 by 3 feet on the top of the high bank on the river side of the dyke. (Elev. 228.93 feet)

I.W.C. 97. - About 1 mile west of Morrisburg, on the embankment of the Morrisburg canal between the canal and the river, at a wide place on the embankment about 100 meters east of the southern bend of the canal. It is an International Boundary Commission bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 9 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 9 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a conspicuous boulder 4 by 4 by 3 feet in size near the middle of the canal dyke and on line from the station to the center of Canada Island. Reference mark No. 2 is a drill hole in a rock showing 1-1/2 by 1-1/2 by 1 feet above ground at about 2 meters north of the top of the bank on the river side of the dyke. Reference mark No. 3 is the center of the first cast-iron snubbing post east of Monument 36. (Elev. 229.43 feet)

I.B.M. 36. - On Morrisburg Canal Dike, opposite the east end of Ogden Island. An International Boundary Commission Reference Monument, it is the top of the momument. (Elev. 231.35 feet)

B.M. MMLVII. - International Boundary Commission's concrete reference monument No. 36, on south bank of Morrisburg canal, 1-1/2 miles west of lock 23 and almost opposite Mrs. Jacob Duval's residence. Bolt set horizontally facing southwest. (Elev. 229.57 feet)

B.M. MMLIV. - Concrete footbridge over weir immediately south of lock 24, Morrisburg canal, 3-1/2 miles west of main corners. Bolt set horizontally in north end face of reinforced concrete girder at east side of bridge, 9 inches above stone coping of wall of weir. (Elev. 231.10 feet)

I.W.C. 103-sub. - At the head of the Morrisburg canal, on the broad part of the dyke between the canal and the St. Lawrence River, about 75 meters south west of the watergate and lock 24, about 13 meters northeast of where the dyke narrows, about 10 meters toward the canal from the river bank of the dyke. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is the 2nd cast-iron snubbing post west of lock 24. Reference mark No. 2 is the first cast-iron snubbing post west of lock 24. Reference mark No. 3 is a drill hole and an arrow pointing toward the station cut in a rock 3 by 3 feet by 1-1/2 feet high on the dyke west of the lock. (Elev. 230.49 feet)

I.B.C. 40. - At Point Three Points, opposite Lieshmans Point. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 234.79 feet)

B.M. MMLII. * Iroquois; International Boundary Commission's concrete reference monument No. 40, 3 miles east of Bank of Montreal, 50 feet south of south fence of Montreal-Toronto highway and opposite the residence of W. G. Robertson. Bolt set horizontally facing river. (Elev. 232.99 feet)

I.W.C. 107-sub. - This station occupies the point at which the mark for station 107-I.W.C. was found. Observations showed that the original station mark had been disturbed and its position could not be held, hence the station is given a new designation. It is on the north shore of the St. Lawrence River about 4 miles west of Morrisburg and about 1/2 mile west of the upper end of Ogden Island. The station is about 6 meters back from the edge of the high bank of the river at a point where a boat-house extends from the high bank to the water's edge. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of an irregular mass of concrete poured between some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a boulder 3 by 3 feet by 1 foot high on the edge of the high bank of the river 3 meters west of the boat-house. Reference mark No. 2 is International Boundary Reference Monument No. 40. (Elev. 229.35 feet)

B.M. 907. - Interior Department B. M. In top of concrete bench mark pier, one mile east of Iroquois, 5 feet north of south line of G. T. Ry. right-of-way, 26 feet east of a farm crossing, and 600 feet east of east end of a plate girder bridge at mileage 235.65 from Toronto. (Elev. 255.43 feet)

I.W.C. 117-sub. - At Iroquois, on the outer pier of lock 25 at the outlet of the Galop Canal. The station is on the stone seawall around the outer end of the pier and near the southeastern part of the semi-circular end of the pier. It is an International Boundary Commission standard bronze-disk station mark set in a drill hole in the deck of the stone seawall. Reference mark No. 1 is the center of the cast-iron snubbing post near the end of the pier. Reference mark No. 2 is a drill hole in the top surface of the seawall on the northern side of and near the eastern end of the pier. (Elev. 234.11 feet)

B.M. MMXLIX. - Iroquois; Curved stone wall at south side of lower entrance to lock 25, Galop canal, in village. Bolt set horizontally, facing east, in third course of stonework below top, 12 feet, 6 inches north of south end of wall. (Elev. 235.00 feet)

B.M. MMXLVII. - Swing highway bridge over Galop canal, at head of lock 25. North stone abutment, west end of south face, 1 foot above coping of canal wall. Bolt set horizontally. (Elev. 246.88 feet)

I.B.C. 43. - North end of Iroquois Point. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 246.89 feet)

I.W.C. 121-sub. - About 1-1/2 miles southwest of Iroquois, on the dyke of the Galop Canal between the canal and the St. Lawrence River, about 125 meters west of where the dyke leaves the land on Iroquois Point. The station is at the top of the high bank on the river side of the dyke. It is an International Boundary Commission standard bronze-disk station mark set flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in the top of a circular block of concrete 10 inches in diameter and 12 inches in depth placed 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock showing 1 by 1-1/2 feet nearly flush with the ground east of the station and one foot below the top of the high bank on the river side of the dyke. Reference mark No. 2 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 1-1/2 feet by 1-1/2 feet high about half way down the slope of the bank to the river. (Elev. 245.71 feet)

I.B.C. 45. - On Toussaints Island. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 239.31 feet)

I.B.C. 46. - On Galop Canal Dike just west of Presqu'ile. An International Boundary Commission Monument. It is the top of the monument. (Elev. 246.95 feet)

B.M. MMXLVII. - International Boundary Commission's concrete reference monument No. 46, on strip of land between Galop canal and St. Lawrence river, 2-1/4 miles east of bridge at entrance to Cardinal and opposite a point 100 feet west of Mrs. Persis Wallace's farm house at north side of Montreal Toronto highway. Bolt set horizontally, facing south. (Elev. 245.28 feet)

B.M. MMXLIV. - Swing highway bridge over Galop canal at entrance to Cardinal. West curved retaining wall at north end of bridge, bolt set horizontally in east face of large block of dressed stone at south end of wall, two feet above sidewalk. (Elev. 278.79 feet)

B.M. MMXLVI. - Curved stone retaining wall at south side of lower entrance to lock on abandoned canal at south side of Benson park. Bolt set horizontally facing east, in third stone from south end of wall and second course below top. (Elev. 242.74 feet)

I.B.C. 48. - On Galop Canal bank just west of Cardinal. An International Boundary Commission Reference Monument. It is the top of the monument. (Elev. 245.72 feet)

B.M. MMXL. - Cardinal; Concrete retaining wall at south side of Galop canal, 1-1/4 miles west of bridge at entrance to Cardinal and 1,050 feet west of upper gate of lock 28. Bolt set horizontally in west face of short wall at right angles to canal, at extreme west end of banal bank wall, 7 feet 8 inches south of inner edge of same and 1 foot below top. (Elev. 247.67 feet)

I.W.C. 129-sub. - About 1-1/2 miles west of Cardinal, on the north bank of the St. Lawrence River, on the most southern bend of the shore line north of Galop Rapids, about 150 meters west of the west end of the concrete

approaches to the upper locks in the Galop Canal. The station is on canal property now leased by a coal company. It is 17 meters east of the line of the east face of the coal company's building, on top of and at the edge of the 25-foot high bank extending along the north side of the canal property, and 4 meters south of the north line fence of the canal property. It is an International Boundary Commission standard bronze-disk station mark set nearly flush with the ground in the top of a cylinder of concrete 10 inches in diameter and 24 inches in depth. The subsurface mark is a brass screw set in a mass of concrete poured between some large rocks 24 inches underground. Reference mark No. 1 is a drill hole and an arrow pointing toward the station cut in a rock 2 by 2-1/2 feet by 1 feet high one meter north of the line fence and at south end of a long line of rocks extending northward. Reference mark No. 2 is a similar mark cut in a large rock showing a surface 2-1/2 by 2 feet flush with the ground in the line of the canal property fence. Reference mark No. 3 is a like mark cut in a rock showing 2 by 2-1/2 feet by 6 inches high one-half meter north of the line fence and north of the station. (Elev. 276.27 feet)

I.W.C. 131-sub. - On the north bank of the St. Lawrence River, 3-1/4 miles west of Cardinal, at the lower end of the "North Channel", opposite the north point of Duck Island. The station is about midway between Ontario Highway No. 2 and the River, and is 4 meters northeast of the fence along the northeast side of a cemetery lying between the highway and the river. It is an International Boundary Commission standard bronze-disk station mark set in a drill hole in the top of a large embedded boulder showing a surface of 2 by 3 feet flush with the ground. There is no subsurface mark. Reference mark No. 1 is a drill hole and an arrow head pointing toward the station cut in a rock showing a 1 by 1 foot surface flush with the ground 1 meter northeast of the cemetery fence and southeast of the station. Reference mark No. 2 is a similar mark on a embedded boulder showing 1-1/2 by 2-1/2 feet by 6 inches high just northeast of the cemetery fence and northwest of the station. (Elev. 279.37 feet)

B.M. MMXXXIV. - Johnstown; At northeast end of long dike extending upstream from head of Spencer island, about 1 mile below Johnstown. Bolt set horizontally in northwest face of concrete retaining wall at southwest side of sluiceway through dike, 5 feet 8 inches from angle of wall and 7 inches below top. (Elev. 248.64 feet)

B.M. MMXXXV. - Johnstown; Steel light beacon at upstream end of long dike extending from head of Spencer island, about 3/4 mile out in St. Lawrence river from Johnstown. Bolt set horizontally in southeast bevelled corner of concrete base, 6 inches above flooring of dike. (Elev. 250.01 feet)

B.M. MMLV. - International Boundary Commission's concrete reference monument No. 52, 2 miles east of post office, 1/4 mile east of Windmill point lighthouse, 115 feet south of south edge of pavement on disused section of Montre Toronto highway and 220 feet east of Arthur Dean's frame cottage. Bolt set horizontally, facing south. (Elev. 255.49 feet)

PART FOUR

LAND ACQUISITION

STATUS OF PRELIMINARY INVESTIGATIONS

Appendix A-2

St. Lawrence River Seaway & Power Project
Land Acquisition
Status of Preliminary Investigations

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
M	International Park	Massena	85.908	X	X					1852-1941 (2)
1	Laura C. Stevens	Massena	169.232	X	X	X	X	X	3	
2	Allen E. & Sophie W. Phillips	Massena	162.106	X	X	X	X	X	1	
3	Allen E., Sophie W. & Ruth H. Phillips	Massena	209.609	X	X	X	X	X	1	
4	David I. & Milley N. Sheets	Massena	53.745	X	X	X	X	X	1	
5	Zenas M. Snow, et al.	Massena	48.376	X	X	X	X	X	1	
6	David I. & Milley N. Sheets	Massena	135.284	X	X	X	X	X	1	
7	Fred A. & Anna C. Bridges	Massena	167.32	X	X	X	X	X	3	
8	Roy D. & Carrie A. Bridges	Massena	111.453	X	X	X	X	X	1	
9	Robert L. & Emma M. Frego	Massena	112.625	X	X	X	X	X	1	
10	Evelyn C. Andrews, et al.	Massena	292.316	X	X	X	X	X	1	
11	Thomas A. & Vivian J. Rickard	Massena	55.914	X	X	X	X	X	3	1822-1941
12	Max C. Carney	Massena	0.349	X	X	X	X	X	1	1822-1941
13	James R. McEwan	Massena	0.445	X	X	X	X	X	1	1822-1941
14	Bertha W. Hulburd	Massena	204.964	X	X	X	X	X	1	
15	Trustees of School District No. 6	Massena	0.152	X	X	X	X	X	1	
16	John H. Murphy	Massena	75.514	X	X	X	X	X	3	
17	Henry P. Clark	Massena	130.910	X	X	X	X	X	1	1883-1932*
18	Minnie C. Brewer	Massena	184.205	X	X	X	X	X	1	
19	Sarah Sea Whitney	Massena	3.776	X	X	X	X	X	1	
20	St. Lawrence River Power Co.	Massena	198.288	X	X	X	X	X	1	
21	Robert L. & Emma M. Frego	Massena	153.848	X	X	X	X	X	3	
22	Sarah J. Horton Estate, et al.	Massena	164.292	X	X	X	X	X	3	
22A	Earnest & Bernice Kallison	Massena	1.290	X	X	X	X	X	1	
22B	Sarah J. Horton Est. Albert Warriner, Contract	Massena	1.000	X	X	X	X	X	1	
23	J. Joseph & Ethel M. Murphy	Massena	167.130	X	X	X	X	X	1	
24	William L. Murphy	Massena	141.963	X	X	X	X	X	1	

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
25	St. Lawrence River Power Co.	Massena	311.566	X	X	X	X	X	3	
26	Frontier Corp. T.—William Lavine	Massena	72.589	X	X	X	X	X	1	
27	Frontier Corp. T.—William Lavine	Massena	100.975	X	X	X	X	X	1	
28	Frontier Corp. T.--Frank Premo	Massena	256.213	X	X	X	X	X	1	
29	Frontier Corp. T.—Fred Boyer	Massena	188.382	X	X	X	X	X	2	
29A	Simeon, Ethel & May Richmire	Massena	0.591	X	X	X	X	X	1	
30	Frontier Corp. T.—Albert Amo	Massena	114.897	X	X	X	X	X	1	
31	Frontier Corp. T.—Albert Amo	Massena	115.123	X	X	X	X	X	1	
32	Edson J. Horton	Massena	13.818	X	X	X	X	X	2	1851-1941
33	Frontier Corp. T.--Fred Boyer	Massena	51.670	X	X	X	X	X	2	
34	Frontier Corp. T.--Fred LaRue	Massena	138.628	X	X	X	X	X	1	
35	Edson J. Horton	Massena	207.009	X	X	X	X	X	1	
36	Mary L. & Leo P. Tyo	Massena	96.775	X	X	X	X	X	3	
37	Silas & Gertrude M. Rush	Massena	1.107	X	X	X	X	X	1	
38	Thomas A. & Vivian J. Rickard	Massena	207.702	X	X	X	X	X	1	
38A	Janet L. & Chauncy G. Cornell	Massena	1.248	X	X	X	X	X	1	
39	Sarah G. & Joseph A. Lamping	Massena	78.575	X	X	X	X	X	3	
40	Orin A. & Charlotte H. Wheeler	Massena	108.012	X	X	X	X	X	3	
41	David O. Donaghue	Massena	87.177	X	X	X	X	X	1	
42	Sarah G. & Joseph A. Lamping	Massena	17.764	X	X	X	X	X	1	
43	Charlotte H. & Orin A. Wheeler	Massena	76.464	X	X	X	X	X	2	1854-1941
43A	Theodore H. & Clara M. Taylor	Massena	0.245	X	X	X	X	X	2	1854-1941
44	Thomas W. & Adelaide S. Rickard	Massena	154.197	X	X	X	X	X	2	1826-1941
46	Fred H. Beaulieu	Massena	3.162	X	X	X	X	X	3	
47	Thomas A. & Vivian J. Rickard	Massena	0.601	X	X	X	X	X	2	
47A	Thomas W. & Adelaide S. Rickard	Massena	0.707	X	X	X	X	X	3	

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
48	Giles J. & Olive Crawford	Massena	0.366	X	X	X	X	X	2	
49	Methodist Church	Massena	0.255	X	X	X	X	X	3	
50	Janet L. & Chauncy Cornell	Massena	0.626	X	X	X	X	X	2	
51	Elizabeth Lavine	Massena	0.208	X	X	X	X	X	2	
52	Arthur Gollinger	Massena	0.270	X	X	X	X	X	3	
53	Guy B. & Laura E. Emmons	Massena	0.492	X	X	X	X	X	3	
54	Maurice L. & Irene G. Dewey	Massena	0.347	X	X	X	X	X	3	
55	William H. & Lois Bashaw	Massena	0.540	X	X	X	X	X	3	1856-1930*
56	Richard W. & Nellie M. Hartford	Massena	0.442	X	X	X	X	X	2	1837-1937*
57	Richard W. & Nellie M. Hartford	Massena	1.383	X	X	X	X	X	3	
58	Horace E. & Margaret V. Gollinger	Massena	0.254	X	X	X	X	X	2	
59	Melvin M. & Alice Frego	Massena	0.264	X	X	X	X	X	3	
60	Thomas W. & Adelaide S. Rickard	Massena	0.115	X	X	X	X	X	2	
61	Gerald M. & Athol Hartford	Massena	0.282	X	X	X	X	X	2	
62	Mervyn H. & Elizabeth J. Taylor	Massena	0.359	X	X	X	X	X	2	
63	Guy B. & Laura E. Emmons	Massena	0.843	X	X	X	X	X	3	
64	Alma Farr	Massena	0.556	X	X	X	X	X	2	
65	Martha Ann Gollinger	Massena	0.493	X	X	X	X	X	3	
66	Margaret Rickard	Massena	0.492	X	X	X	X	X	3	
67	Baptist Church	Massena	0.695	X	X	X	X	X	2	
68	Sheridan A. & Ella Alden	Massena	0.258	X	X	X	X	X	3	
69	Jack E. & June L. Kennedy	Massena	0.386	X	X	X	X	X	2	
70	Trustees of School District No. 5	Massena	0.170	X	X	X	X	X	2	
71	Methodist Church	Massena	0.185	X	X	X	X	X	2	
72	Maurice L. & Irene G. Dewey	Massena	0.413	X	X	X	X	X	2	
73	May S. Burpee	Massena	0.336	X	X	X	X	X	2	
75	May S. Burpee	Massena	77.478	X	X	X	X	X	3	1808-1941
76	Alma Farr	Massena	9.844	X	X	X	X	X	3	
77	Thomas W. & Adelaide S. Rickard	Massena	24.260	X	X	X	X	X	3	1826-1941

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
78	Joseph G. Lamping	Massena	115.035	X	X	X	X	X	3	1850-1941
79	Floyd E. Horton	Massena	164.042	X	X	X	X	X	3	1840-1941
80	Rupert J. Bezanson	Massena	1.431	X	X	X	X	X	3	1851-1941
81	Myrtle A. Pollock	Massena	29.413	X	X	X	X	X	3	1851-1941
82	Elisha Hackett	Massena	2.750	X	X	X	X	X	3	1859-1941
83	Ruth L. Hackett	Massena	70.332	X	X	X	X	X	3	1854-1941
84	Dodge Estate	Massena	117.477	X	X	X	X	X	3	1832-1941
85	Ira M. Smith	Massena	88.996	X	X	X	X	X	3	1865-1941
86	David O. Donaghue	Massena	59.621	X	X	X	X	X	3	1852-1941
87	Kate Polley	Massena	123.970	X	X	X	X	X	1	1836-1941
88	Luman A. & Maude Hackett	Massena	110.106	X	X	X	X	X	1	
89	Myrtle A. Pollock	Massena	61.579	X	X	X	X	X	1	
90	Ruth L. Hackett	Massena	55.562	X	X	X	X	X	1	
91	Alice G. Gaines	Massena	72.636	X	X	X	X	X	3	
92	Sarah J. Horton Est. et al.	Massena	103.762	X	X	X	X	X	2	1847-1941
92A	Trustees of School District No. 12	Massena	0.241	X	X	X	X	X	1	
93	Frontier Corp. T.--Fred LaRue	Massena	40.288	X	X	X	X	X	1	
94	Frontier Corp. T.--Fred Boyer	Massena	42.031	X	X	X	X	X	2	
95	Frontier Corp. T.--Harold Premo	Massena	9.227	X	X	X	X	X	2	
96	Frontier Corp. T.--John Vice	Massena	70.692	X	X	X	X	X	1	
97	Frontier Corp. T.--Harold Premo	Massena	26.906	X	X	X	X	X	1	
98	Hiram McLellan & Laura M. Provost	Massena	116.964	X	X	X	X	X	1	1853-1941
99	John F. Sutton	Massena	106.037	X	X	X	X	X	3	1853-1941
100	Claude Kezar	Massena	92.838	X	X	X	X	X	2	
101	Frontier Corp.	Massena	5.322	X	X	X	X	X	2	
102	Frontier Corp. T.--Harold Premo	Massena	54.603	X	X	X	X	X	1	
103	Frontier Corp. T.--Clifford Jock	Massena	151.837	X	X	X	X	X	1	

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
104	Frontier Corp. T.—John Vice	Massena	117.394	X	X	X	X	X	1	
105	Bernice M. Brubaker	Massena	367.923	X	X	X	X	X	3	
106	Burt & Etta Brown	Massena	42.594	X	X	X	X	X	3	1851-1941
107	Joseph J. Houle	Massena	50.557	X	X	X	X	X	2	1824-1941
108	Joseph J. Houle	Massena	75.504	X	X	X	X	X	2	1824-1941
108A	Charles & Elsie Ramsey	Massena	6.047	X	X	X	X	X	1	1848-1941
109	Arthur L. Tracy & Hazel Hartford	Massena	123.811	X	X	X	X	X	2	1840-1938*
111	Harold S. Cobane	Massena	2.612	X	X	X	X	X	1	
112	Herbert & Elizabeth Sutton	Massena	79.720	X	X	X	X	X	3	
113	Simeon, Ethel & May Richmire	Massena	51.460	X	X	X	X	X	2	
114	Claude A. Kezar	Massena	78.820	X	X	X	X	X	1	1844-1941
115	Joseph J. Houle	Massena	47.387	X	X	X	X	X	2	1824-1941
116	Roy & Maude Alden	Massena	100.297	X	X	X	X	X	3	1849-1941
117	Floyd B. & Junelle B. Hopson	Massena	257.561	X	X	X	X	X	3	1841-1941
117A	Trustees of School District No. 4	Massena	0.475	X	X	X	X	X	1	
118	Ella Robillard	Massena	90.221	X	X	X	X	X	3	1838-1941
119	Louise H. & Frederick Mason	Massena	90.059	X	X	X	X	X	3	1823-1921*
120	Walter & Edna Hutchins	Massena	86.006	X	X	X	X	X	3	1892-1939*
121	Ross C. & Thelma Miller	Massena	1.250	X	X	X	X	X	1	
122	Leo E. & Pearl Compo	Massena	1.000	X	X	X	X	X	1	
123	Frederick J. & Hazel Collins	Massena	1.000	X	X	X	X	X	1	
124	Goldie Fay & Albert Bunt	Massena	1.000	X	X	X	X	X	1	
125	Richard Bunt	Massena	1.000	X	X	X	X	X	1	
126	John F. Sutton	Massena	2.908	X	X	X	X	X	1	1893-1939*
127	Steve Syakos Arthur J. Tupper--Contract	Massena	1.000	X	X	X	X	X	1	
127A	Steve Syakos A. J. Tupper--Option	Massena	0.801	X	X	X	X	X	1	
128	Steve Syakos	Massena	117.334	X	X	X	X	X	1	1893-1937*
129	Walter H. & Edna Hutchins	Massena	12.050	X	X	X	X	X	1	
130	Portolese & Elizabeth Savario	Massena	1.054	X	X	X	X	X	1	
131	Joseph & Mary Grillo	Massena	1.064	X	X	X	X	X	1	
132	Mildred I. Fenstermaker	Massena	1.291	X	X	X	X	X	1	

*Photostat Copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
133	Louise H. & Frederick Mason	Massena	116.849	X	X	X	X	X	3	
134	Edward D. & Helen Lewis	Massena	1.196	X	X	X	X	X	1	
135	St. Lawrence River Power Co.	Massena	33.945	X	X	X	X	X	1	
136	St. Lawrence River Power Co.	Massena	13.205	X	X	X	X	X	1	
137	St. Lawrence River Power Co.	Massena	6 888	X	X	X	X	X	1	
138	St. Lawrence River Power Co.	Massena	20.620	X	X	X	X	X	1	
139	St. Lawrence River Power Co.	Massena	37.151	X	X	X	X	X	1	
140	Frontier Corp.	Massena	3.847	X	X	X	X	X	1	
141	Frontier Corp.	Massena	0.584	X	X	X	X	X	1	
142	Frontier Corp.	Massena	0.584	X	X	X	X	X	1	
143	Weston V. Cline	Massena	40.195	X	X	X	X	X	1	
144	McDonell Heirs	Massena	95.319	X	X	X	X	X	1	
145	St. Lawrence River Power Co.	Massena	5.330	X	X	X	X	X	1	
146	Board of Missions Protestant Epis. Church	Massena	1.545	X	X	X	X	X	1	
147	Frontier Corp.	Massena	1587.735	X	X	X	X	X	1	
147A	Frontier Corp.	Massena	401.430	X	X	X	X	X	1	
147B	Frontier Corp.	Massena	21.757	X	X	X	X	X	1	
147C	Frontier Corp.	Massena	307.362	X	X	X	X	X	1	
148	Horace G. Atwater	Massena	85.866	X	X	X	X	X	1	
149	Catherine H. Stafford	Massena	223.176	X	X	X	X	X	1	
150	Riley & Stella Cuglar	Massena	211.289	X	X	X	X	X	1	
150A	School District No. 10	Massena	0.217	X	X	X	X	X	1	
151	Herbert V. Sutton	Massena	110.755	X	X	X	X	X	1	
152	Gordon Miller Estate	Massena	85.070	X	X	X	X	X	1	
153	Raymond B. Barnes	Massena	153.249	X	X	X	X	X	1	
154	Seth C. Miller	Massena	2.270	X	X	X	X	X	1	
155	Sidney H. Miller	Massena	60.769	X	X	X	X	X	1	
156	John F. Sutton	Massena	56.936	X	X	X	X	X	1	
157	Gordon Miller Est.	Massena	96.062	X	X	X	X	X	1	
158	John F. Sutton	Massena	117.247	X	X	X	X	X	1	
159	Frontier Corp.	Massena	53.346	X	X	X	X	X	1	
160	St. Lawrence River Power Co.	Massena	5.896	X	X	X	X	X	1	
161	Town of Massena Cemetery	Massena	0.448	X	X	X	X	X	1	
162	M. E. Church	Massena	0.301	X	X	X	X	X	1	
163	Jason Monroe	Louisville	93.470	X	X	X	X	X		
164	Louis Charles Phelix	Louisville	9.814	X	X	X	X	X		

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
165	Henry P. Clark	Louisville	241.815	X	X	X	X	X		
166	Thomas Finney	Louisville	93.218	X	X	X	X	X		
167	James I. Brown	Louisville	11.906	X	X	X	X	X		
168	James Cross	Louisville	165.420	X	X	X	X	X		
	T.--Frank Donnell									
169	Arnold A. Cross	Louisville	141.879	X	X	X	X	X		1861-1932*
	T.—Oral Monroe									
170	Allan G. Robertson	Louisville	105.070	X	X	X	X	X		
171	Barnett J. Browning Est.	Louisville	57.464	X	X	X	X	X		
172	William A. Castleman	Louisville	107.866	X	X	X	X	X		
173	William Laguee	Louisville	94.269	X	X	X	X	X		
	T.--Allan Robertson									
174	School Dist. No. 3	Louisville	0.141	X	X	X	X	X		
175	Amos H. Warren	Louisville	99.844	X	X	X	X	X		
176	Barnett J. Browning Est.	Louisville	223.248	X	X	X	X	X		
177	Thorold S. Cross	Louisville	99.395	X	X	X	X	X		
178	James I. Brown	Louisville	175.300	X	X	X	X	X		
179	Grant D. Robertson	Louisville	100.825	X	X	X	X	X		
180	Town of Louisville	Louisville	2.345	X	X	X	X	X		
181	Frontier Corp.	Massena	3.241	X	X	X	X	X	1	
W-1	Leslie Clark	Waddington	111.570	X	X	X	X	X	1	1887-1940*
W-2	Mrs. Cora Keck	Waddington	27.892	X	X	X	X	X		
W-3	Clarence Carnal	Waddington	18.538	X	X	X	X	X		
W-4	Fred J. Gray	Waddington	79.853	X	X	X	X	X	1	1802-1921*
W-5	Alma E. Ward	Waddington	78.684	X	X	X	X	X	1	
W-6	Daniel T. McMahon	Waddington	99.747	X	X	X	X	X	1	1854-1927*
W-7	Barton H. Edsall	Waddington	104.569	X	X	X	X	X	1	
W-8	Merton E. Dunn	Waddington	54.522	X	X	X	X	X	1	
W-9	Clinton J. Green	Waddington	4.821	X	X	X	X	X		
W-10	Florence W. Dunlop (Cottage Lot)	Waddington	0.199	X	X	X	X	X	1	
W-11	Roy Bradley (Cottage Lot)	Waddington	0.255	X	X	X	X	X	1	
W-12	Annette & Mary Burlingame, et al.	Waddington	103.586	X	X	X	X	X	1	
W-13	Kenneth G. Castle	Waddington	85.514	X	X	X	X	X	1	1853-1914*
W-14	Frank Hoh (Cottage Lot)	Waddington	0.954	X	X	X	X	X	1	

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
W-15	Clara Mitchell	Waddington	154.384	X	X	X	X	X	1	
W-16	Harry A. Carnal	Waddington	173.324	X	X	X	X	X	1	
W-17	Waddington Bank Kenneth A. Myers—Tenant	Waddington	130.337	X	X	X	X	X	1	1854-1939*
W-18	Colin Crobar	Waddington	60.549	X	X	X	X	X	1	
W-19	William F. Henderson	Waddington	54.235	X	X	X	X	X	1	1890-1920*
W-20	Clyde B. Scott	Waddington	40.174	X	X	X	X	X	1	
W-21	Waddington Bank	Waddington	65.829	X	X	X	X	X	1	1866-1940*
W-22	M. E. Church--Nelson Sheets, Tenant	Waddington	73.634	X	X	X	X	X	1	
W-23	William F. Henderson	Waddington	13.258	X	X	X	X	X		1815-1920*
W-24	James K. Mulloy	Waddington		X	X	X				
W-25	E. C. Arbuckle Estate	Waddington		X	X	X				
W-26	Arthur Duval	Waddington		X	X	X				
W-27	Fred A. Sweet	Waddington	12.626	X	X	X	X	X	1	
W-28	Floyd Sheff	Waddington		X	X	X				
W-29	Almeda Kentner	Waddington	11.249	X	X	X	X	X	1	1881-1914*
W-30	Floyd C. Dunn	Waddington	26.745	X	X	X	X	X	1	1811-1937*
W-31	School Dist. #2	Waddington	0.378	X	X	X	X	X	1	
W-32	Ira E. Morgan	Waddington	31.795	X	X	X	X	X	1	
W-33	Lydia Sharpe	Waddington	36.214	X	X	X	X	X	1	
W-34	Merton Putney Estate	Waddington	17.390	X	X	X	X	X	1	
W-35	Almeda Kentner	Waddington	82.128	X	X	X	X	X	1	1869-1914*
W-36	George L. Charlton	Waddington	20.087	X	X	X	X	X	1	
W-37	Elizabeth S. Simonds	Waddington	52.514	X	X	X	X	X	1	
W-38	Samuel A. Logan	Waddington		X	X	X				
W-39	Nellie M. Whalen	Waddington		X	X	X				1859-1924*
W-40	John C. Crapser, et al	Waddington		X	X	X				
W-41	John Porteous	Waddington		X	X	X				
W-42	Walter S. Connolly	Waddington		X	X	X				
W-43	Mrs. L. L. Smith	Waddington		X	X	X				
W-44	Walter S. Connolly	Waddington		X	X	X				
W-47	Charles Murphy	Waddington	21.637	X	X	X	X	X	1	
L-1	Jeanette McBath	Lisbon	10.101	X	X	X	X	X		1837-1916*
L-2	William W. Clements	Lisbon	9.929	X	X	X	X	X		
L-3	George W. Clements	Lisbon	1.320	X	X	X	X	X		

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
L-4	William W. Clements	Lisbon	10.847	X	X	X	X	X		
L-5) L-5A)	Otis Elisha Sanderson	Lisbon	15.439	X	X	X	X	X X		
L-6) L-6A)	Leslie E. Putney	Lisbon	12.798	X	X	X	X	X X		
L-7) L-7A)	Myron E. Putney	Lisbon	5.166	X	X	X	X	X X		
L-8	Fred J. Gray	Lisbon	1.550	X	X	X	X	X		
L-9) L-9A)	Edward J. Burns	Lisbon	2.583	X	X	X	X	X X		
L-10	Ellery G. Boice	Lisbon	8.782	X	X	X	X	X	1	
L-10A	Mary D. Boice	Lisbon	3.672	X	X	X	X	X	1	
L-11	Omer McIver	Lisbon	21.866	X	X	X	X	X	1	
L-12	Fred J. Gray	Lisbon	5.280	X	X	X	X	X	1	
L-13	William R. Binion	Lisbon	13.831	X	X	X	X	X	1	
L-14	Wallace O. Veitch	Lisbon	19.342	X	X	X	X	X	1	
L-14A	John Wagner Estate	Lisbon	1.033	X	X	X	X	X	1	
L-15	Jay C. Dawley Estate	Lisbon	11.306	X	X	X	X	X	1	
L-16	Herbert J. Randles	Lisbon	14.692	X	X	X	X	X	1	
L-17	Homer A. Hanna	Lisbon	85.514	X	X	X	X	X	1	
L-18	Robert M. Purvis	Lisbon	72.371	X	X	X	X	X	1	
L-19	Wallace Hyde	Lisbon	49.701	X	X	X	X	X	1	
L-20	Neal William Dewley	Lisbon	35.755	X	X	X	X	X	1	
L-21	Lee W. Keyes	Lisbon		X	X	X				
L-22	Mrs. Bessie J. Russell	Lisbon		X	X	X				
L-23	Lillian E. LeRoux	Lisbon		X	X	X				
L-24) L-24A)	Ernest Lalone	Lisbon	17.676	X	X	X	X	X X	1	
L-25	Roy C. Binion	Lisbon	7.002	X	X	X	X	X	1	
L-26	Lisbon School District #15	Lisbon	0.861	X	X	X	X	X	1	
L-27	Margaret R. Binion	Lisbon	11.364	X	X	X	X	X	1	
L-28	Fred G. Duvall	Lisbon	13.028	X	X	X	X	X	1	
L-29	David E. Clements	Lisbon	37.247	X	X	X	X	X	1	
L-30	George E. McCarthy	Lisbon		X	X	X				
L-31	John McWilliams	Lisbon		X	X	X				1807-1920*
L-32	Alfred J. Willard	Lisbon		X	X	X				

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
L-33	Peter Valois	Lisbon		X	X	X				
L-34	M. O. Calway & M. S. Purvis	Lisbon		X	X	X				
L-34A	Marion S. Purvis	Lisbon		X	X	X				
L-34B	Marion O. Calway	Lisbon		X	X	X				
L-35	Nettie A. O'Neil (George L. Griffith by Contract)	Lisbon		X	X	X				
L-36	Mrs. Ida E. McCormick	Lisbon		X	X	X				
L-37	Jay F. Thompson	Lisbon		X	X	X				
L-38	Arthur J. Harper	Lisbon		X	X	X				1893-1936*
L-39	James A. Fisher	Lisbon		X	X	X				1848-1941*
L-40	William J. Duskas	Lisbon		X	X	X				
L-41	James R. Sears	Lisbon		X	X	X				1816-1940*
L-42	Ralph Tallman	Lisbon		X	X	X				
L-43	Charles P. Erney	Lisbon		X	X	X				
L-44	Florence M. Wallace	Lisbon		X	X	X				
L-45	Paul A. LeRoux	Lisbon		X	X	X				
L-45a	Ruth M. Simpson	Lisbon		X	X	X				
L-46	Roger W. Runion	Lisbon		X	X	X				
L-47	Phoebe H. Davies	Lisbon		X	X	X				
L-48	Charles Grenier	Lisbon		X		X				
L-49	Ernest G. Bouchard	Lisbon		X	X	X				1899-1941*
L-50	Christopher J. McNeil	Lisbon		X	X	X				
L-51	Chester A. Harper	Lisbon		X	X	X				
L-52	Homer S. Rolfe	Lisbon		X	X	X				
L-53	Laura [illegible]. Sutherland	Lisbon		X	X	X				
L-54	Lawrence LaFlair	Lisbon		X	X	X				
L-55	Mary M. Carswell	Lisbon		X	X	X				1836-1889*
L-56	Stanley D. Richardson	Lisbon		X	X	X				
L-57	William H. Richardson	Lisbon		X	X	X				
L-58	Homer S. Rolfe	Lisbon		X	X	X				
L-59	Edward LaFlair	Lisbon		X	X	X				
L-60	Mary Dawson	Lisbon		X	X	X				
L-61	Ernest O. Havens	Lisbon		X	X	X				
L-62	Earl William Porter	Lisbon		X	X	X				
L-63	School District No. 19	Lisbon		X	X	X				

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
L-64	Merrill M. Watson	Lisbon		X	X	X				
L-65	Kenneth McDonald	Lisbon		X	X	X				
L-67	Henry S. Miller	Lisbon		X	X	X				
L-68	Arthur D. Reagan	Lisbon		X	X	X				
L-69	John G. Ward	Lisbon		X	X	X				
L-70	Clement A. McDonald	Lisbon		X	X	X				
L-71	Edgar McDonald	Lisbon		X	X	X				
L-72	Lawrence McDonald	Lisbon		X	X	X				
L-73	Warren H. Jones	Lisbon		X	X	X				
L-74	Herbert P. Hannan	Lisbon		X	X	X				
L-75	Artnur P. Wagner	Lisbon		X	X	X				
L-76	Albert Appleyard	Lisbon		X	X	X				
L-77	William J. Cruikshank Estate	Lisbon		X	X	X				
L-90	City of Ogdensburg (Chimney Island)	Lisbon		X	X	X	X			
L-91	Homer S. Rolfe (Butternut Island)	Lisbon		X	X	X	X			
L-92	Irving H. Griswold (Tick Island)	Lisbon		X	X	X	X			
L-93	Angus William Fraser (dam) (Galop Island)	Lisbon		X	X	X	X			
L-94	Mrs. Mary A. Carswell (Galop Island)	Lisbon		X	X	X	X			1861-1883*
L-95	Richard L. Frank (Dixon Island)	Lisbon		X	X	X	X			
L-96	(Benedict Island)	Lisbon								
L-97	Jenny F. Westbrook Estate (Sears Island)	Lisbon		X	X	X	X			
L-98	Walter G. Kellogg (Little Sears Island) (Kellogg's Is.)	Lisbon		X	X	X	X			
L-99	George A. Dillingham Heirs (Baycraft Island) (Dillingham Is.)	Lisbon		X	X	X	X			

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
L-100	Florence McIntosh, et al. (Twin Island)	Lisbon		X	X	X	X			1882-1913*
L-101	Florence McIntosh, et al. (Round Island)	Lisbon		X	X	X	X			1871-1903*
L-102	(Rock Island)	Lisbon								
L-103	Mary J. Sparrowhawk, et al. (Lalone Island)	Lisbon		X	X	X	X			
L-104	Maurice L. Speer, et al. (Lalone Island)	Lisbon		X	X	X	X			
L-105	Anna Smithers, et al. (Lalone Island)	Lisbon		X	X	X	X			
L-106	Myron E. Putney, et al. (Lotus Island)	Lisbon		X	X	X	X			1894-1925*
L-107	State of New York (Lotus Island)	Lisbon		X	X	X	X			
	Waddington Village, Between Canal St. and St. Lawrence River									
	St. Lawrence County	Waddington		X	X					
	Frontier Corp.	Waddington		X	X					
	Walter S. Connolly	Waddington		X	X					
	George Dickson	Waddington		X	X					
	John S. Rutherford Est.	Waddington		X	X					
	Joel M. Howard	Waddington		X	X					
	Ray C. Rutherford	Waddington		X	X					
	W. H. Burdick	Waddington		X	X					
	Alexander Forbes' Heirs	Waddington		X	X					
	Margaret Montgomery	Waddington		X	X					
	Heirs of Thomas Dardis	Waddington		X	X					
	John S. Rutherford Est.	Waddington		X	X					
	John S. Rutherford Est., et al	Waddington		X	X					
	Waddington Village - North Side of River Road									
	Samuel F. Carlisle	Waddington		X	X					

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	Wm. H. Campbell	Waddington		X	X					
	Orman J. Spurback	Waddington		X	X					
	Arthur LaVier	Waddington		X	X					
	Chas. W. Condlin, et al	Waddington		X	X					
	Robert W. Hatch	Waddington		X	X					
	Wm. W. Proctor Est.	Waddington		X	X					
	L. Belle Carlisle	Waddington		X	X					
	Wm. A. Taylor	Waddington		X						
	Fred H. Martin	Waddington		X						
	Effie E. Martin	Waddington		X	X					
	Joan Hitsman	Waddington		X	X					
	Harvey L. McBride	Waddington		X	X					
	Clara A. Martin	Waddington		X	X					
	Ernest A. Fay	Waddington		X	X					
	Chesley W. Hanes, et al	Waddington		X	X					
	George Hall Corp.	Waddington		X	X					
	Anna R. Clark, et al	Waddington		X	X					
	Waddington Bank	Waddington		X	X					
	Flossie M. Hanson	Waddington		X	X					
	Texenia Scott	Waddington		X	X					
	John M. Doyle	Waddington		X	X					
	Lloyd Bashaw	Waddington		X	X					
	Thomas Wallace	Waddington		X	X					
	Donald F. Hanson	Waddington		X	X					
	Mary A. Hanson	Waddington		X	X					
	Sarah E. Brown	Waddington		X	X					
	Lucinda Myers	Waddington		X	X					
	Jessie S. McDowell	Waddington		X	X					
	John S. Rutherford Est.	Waddington		X	X					
	Louise M. Shaver	Waddington		X	X					
	Fanny E. McKay	Waddington		X	X					
	Anna R. Clark, et al	Waddington		X	X					
	Alva B. Rutherford	Waddington		X	X					
	Ross H. Thompson	Waddington		X	X					
	Edward A. Jones	Waddington		X	X					
	Geo. Roach Est.	Waddington		X	X					

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	Frank L. Murphy, et al	Waddington		X	X					
	Guy V. Doran	Waddington		X	X					
	Christene S. Johns	Waddington		X	X					
	Bessie M. Fitzgerald	Waddington		X	X					
	Chas. A. Creighton	Waddington		X	X					
	Waddington Village - South Side of River Road									
	Edith Fulton	Waddington		X	X					1778-1894* 1859-1904*
	Frank R. Maloney Est.	Waddington		X	X					
	Wm. H. Campbell	Waddington		X	X					
	Fred W. Martin	Waddington		X	X					
	Elizabeth C. Arbuckle Est.	Waddington		X	X					
	Chas. S. Henderson	Waddington		X	X					
	E. Frances Duffy	Waddington		X	X					
	Sarah H. Porteous	Waddington		X	X					
	Merton S. Redick, et al	Waddington		X	X					
	Sarah H. Porteous	Waddington		X	X					
	George H. Hunter	Waddington		X	X					
	Helen F. Logan, et al	Waddington		X	X					
	L. Belle Carlisle	Waddington		X	X					
	Wm. L. Forsythe	Waddington		X	X					
	John R. Wright	Waddington		X	X					
	Grace S. Short	Waddington		X	X					
	Bertha L. Carruthers	Waddington		X	X					
	Teresa M. Duffy, et al	Waddington		X	X					
	Waddington Grange #980	Waddington		X	X					
	Silas J. Bowers Est.	Waddington		X	X					
	Robt. W. Thompson, Jr., et al	Waddington		X	X					
	Waddington Masonic Lodge No. 393	Waddington		X	X					
	Waddington Bank	Waddington		X	X					
	Robert W. Thompson, Jr., et al	Waddington		X	X					
	Gertrude E. Colvin	Waddington		X	X					
	Winfield S. Rutherford	Waddington		X	X					

*Photostat copy of original.

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	Sarepta Rutherford Est.	Waddington		X	X					
	Eunice E. Crapser, et al	Waddington		X	X					
	Wm. P. Hanna, et al	Waddington		X	X					
	Ernest A. Fay	Waddington		X	X					
	Elizabeth Dalzell Est.	Waddington		X	X					
	Carrie H. Brookins	Waddington		X	X					
	Belle H. Russell	Waddington		X	X					
	Irene B. Tedford	Waddington		X	X					
	Hugh Downey	Waddington		X	X					
	Carrie E. Prashaw	Waddington		X	X					
	Adeline Moore	Waddington		X	X					
	Margaret Montgomery	Waddington		X	X					
	Roy H. Wilson	Waddington		X	X					
	Bertha F. LaPointe	Waddington		X	X					
	Hugh P. McNulty	Waddington		X	X					
	Percy P. McMillan	Waddington		X	X					
	Anna O'Brien Est.	Waddington		X	X					
	Ann S. Creighton	Waddington		X	X					
	Village of Waddington	Waddington		X	X					
	Town of Waddington, East of Waddington Village									
	Geo. M. Dickson, et al	Waddington		X						
	Francis L. Murphy, et al	Waddington		X						
	Chesley W. Hanes	Waddington		X						
	Town of Louisville, Easterly Line to Westerly Line (River Lots #1 Through #59)									
	Merton I. Simser	Louisville		X						
	St. Lawrence River Power Co.	Louisville		X						1841-1889*
	Murland R. Lowell	Louisville		X						
	Frank Blanchette	Louisville		X						
	Frank Blanchette, Jr.	Louisville		X						
	Bernard M. Tyo	Louisville		X						
	Garrett M. Lawrence	Louisville		X						

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	St. Lawrence River Power Co.	Louisville		X						
	Leboire Hurteau	Louisville		X						
	John J. Richards	Louisville		X						
	Hawes Lumber Corp.	Louisville		X						
	Fred N. Sharples	Louisville		X						
	Herbert L. Hall	Louisville		X						
	Gordon T. Scott	Louisville		X						
	Sidney W. Carville	Louisville		X						
	Donald G. Grant	Louisville		X						1881-1938*
	Merton I. Simser	Louisville		X						1881-1937*
	Carrie P. Simser	Louisville		X						
	Harold M. Nichols	Louisville		X						
	Lloyd Hosmer	Louisville		X						
	Birdie Browning	Louisville		X						
	Barnett J. Browning Est.	Louisville		X						1886-1939*
	Samuel J. Browning	Louisville		X						
	Harry Weegar Est. (to Leo H. Garloch, Contract)	Louisville		X						
	Merton J. Raymond Est.	Louisville		X						
	Sophia M. Stinzing Est.	Louisville		X						
	Elizabeth Tucker	Louisville		X						
	Geo. L. Sutton	Louisville		X						
	Minard H. Power	Louisville		X						1884-1935*
	Edgar J. Casaw	Louisville		X						
	Mary M. Willard	Louisville		X						
	Mary F. Quenell	Louisville		X						1882-1925*
	James Wm. Phelix	Louisville		X						
	James Cross	Louisville		X						
	Clara G. Sale	Louisville		X						
	Patience Haggard	Louisville		X						
	Gertrude M. Harkness	Louisville		X						
	John Davidson	Louisville		X						
	Margaret H. Weaver	Louisville		X						
	Wm. A. Casselman	Louisville		X						
	Jessie E. Gibson	Louisville		X						
	Jessie E. Gibson(to C.Andress on contract)	Louisville		X						

*Photostat copy of original

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	John Spence	Louisville		X						
	Edgar F. Gibson	Louisville		X						
	Florence M. Cook	Louisville		X						
	Leon J. Forbes	Louisville		X						
	Chas. E. Steinbarge	Louisville		X						
	Fortuna P. Major	Louisville		X						
	Ida M. Hodge	Louisville		X						
	John M. Weegar	Louisville		X						
	Thos. H. Finnie	Louisville		X						
	Sue S. Matthews	Louisville		X						
	Thos. H. Finnie	Louisville		X						
	Sue S. Matthews	Louisville		X						
	Leslie E. Schall	Louisville		X						
	Charles McGee	Louisville		X						
	Arthur M. Langlois	Louisville		X						
	Levi J. Jesmer	Louisville		X						
	Pearl W. Segar	Louisville		X						
	Harriet M. Armstrong	Louisville		X						
	John M. Weegar	Louisville		X						
	Frontier Corporation	Louisville		X						
	Charles Boots, Sr.	Louisville		X						
	Frontier Corporation	Louisville		X						
	Carrie M. Weegar	Louisville		X						
	Bartholomew Carroll	Louisville		X						
	John S. Hatton	Louisville		X						
	Louise H. Mason	Louisville		X						
	Raymond T. Whitzel	Louisville		X						
	Thos. P. Carroll	Louisville		X						
	Chas. E. Whalen, Est.	Louisville		X						
	Lydia J. Singleton	Louisville		X						
	Wm. Whalen Est.	Louisville		X						
	Violet W. Wareing, et al	Louisville		X						
	Erwin G. Schoeffel	Louisville		X						
	Dr. Geo. J. Haley	Louisville		X						
	Raymond J. Barstow	Louisville		X						
	Earl J. Mattis	Louisville		X						

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	[illegible]	[illegible]	Appraisal Completed (No.)	Abstract Secured
	James Whalen	Louisville		X						1901-1939*
	Carman B. Bradshaw	Louisville		X						*
	Glenn G. Green	Louisville		X						*
	Warren P. Evans	Louisville		X						*
	Geo. G. St.Amand	Louisville		X						*
	Wm. T. Ennor	Louisville		X						*
	Edgar J. Holcomb	Louisville		X						*
	Preston H. S. Chapman	Louisville		X						*
	John Wm. Leary	Louisville		X						*
	Henry J. King	Louisville		X						*
	Fay A. Soults	Louisville		X						*
	Ralph M. Johns	Louisville		X						*
	Glenford B. Wing	Louisville		X						*
	Frank Kuras	Louisville		X						*
	Roy H. Contryman	Louisville		X						*
	Wm. G. Hawes, Jr.	Louisville		X						*
	Frank Mittiga	Louisville		X						*
	Walter F. Willson (to Geo. W. Browning on Contract)	Louisville		X						
	John B. Willson Heirs	Louisville		X						
	Chas. S. Stephenson	Louisville		X						
	Virgil E. Waldruff	Louisville		X						
	Geo. M. Stone, et al	Louisville		X						
	Beulah K. Helmer	Louisville		X						
	Lulu & Lity Belair	Louisville		X						
	Francis Sutter	Louisville		X						
	Louis J. Honer	Louisville		X						
	Wm. Whalen Est.	Louisville		X						
	Clark J. Willson	Louisville		X						
	Chas. P. Lawrence	Louisville		X						
	Irving M. Carbino	Louisville		X						
	Donald S. Raney	Louisville		X						
	Oswald P. Coleman	Louisville		X						
	Wm. Bashaw	Louisville		X						
	Samuel Waldruff	Louisville		X						

*The abstract covers all parcels so marked, the parcels listed immediately under James Whalen are from his original abstracted property.

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	James D. Bradford	Louisville		X						
	Samuel P. Bradford Est.	Louisville		X						
	Gordon F. Denman	Louisville		X						
	Mary R. Bradford	Louisville		X						
	Pauline E. Lawrence	Louisville		X						
	Royal W. Lawrence	Louisville		X						
	Hattie M. Haggett	Louisville		X						
	Samuel I. Lawrence	Louisville		X						
	Harold D. Cole	Louisville		X						
	Hattie M. Heague, et al	Louisville		X						
	Francis L. Murphy, et al	Louisville		X						
	Thomas Lavigne	Louisville		X						
	Wm. F. Borrman	Louisville		X						
	W. C. Bidwell	Louisville		X						
	Cornelius P. McCormick, et al Cornelius J. McCormick	Louisville		X						
	Leo R. Donovan	Louisville		X						
	Noble M. Powell	Louisville		X						
	Frontier Corporation	Louisville		X	In Deed Book					
	Herbert A. Carr	Louisville		X						
	Susan A. Rutley	Louisville		X						
	Clayton E. Castle	Louisville		X						
	Fred R. Dickson, et al	Louisville		X						
	Town of Louisville Islands in St. Lawrence River									
	Geo. E. VanKennen Est., (Comfort Island)	Louisville		X						
	George E. VanKennen Est., (Treasure Island)	Louisville		X						
	Frontier Corp. (Chyrsler Island)	Louisville		X						
	Nellie E. Lawrence, et al (Strawberry Island)	Louisville		X						

Parcel No.	Name of Owner	Town	Acreage	Deed Descr. Secured	Deed Descr. Plotted	Surveyed	Plat Map Drawn	Legal Descr. Written	Appraisal Completed (No.)	Abstract Secured
	Frontier Corp. (Gooseneck Island)	Louisville		X						
	Francis L. Murphy, et al (Gooseneck Island)	Louisville		X						
	Martha O'Connor Farrand (Gooseneck Island)	Louisville		X						
	Herbert H. Hatch (Gooseneck Island)	Louisville		X						
	Susan A. Rutley (Egg Island)	Louisville		X						
	South Side of Grass and St. Lawrence Rivers, Opposite Massena Point and Cornwall Island--Railroad Relocation Area									
	Hugh H. Kingsley	Massena		X						
	Grace T. Richards	Massena		X						
	Francis J. Fregoe	Massena		X						
	Harvey A. Tucker	Massena		X						
	Ethel M. Haverstock	Massena		X						
	Forest P. Chase	Massena		X						
	Edward S. Napolis, et al	Massena		X						
	Canadian-American Terminals, etc.	Massena		X						
	Cornwall-Northern New York International Bridge Corp.	Massena		X						
	Rollin A. Newton	Massena		X						
	South side of Grass River Opposite Aluminum Plant									
	Annie D. Bayley	Massena		X						
	St. Lawrence River Power Co.	Massena		X						
	Wm. O. Baxter	Massena		X						
	Wm. V. Clemens	Massena		X						
	Elizabeth R. Tyo	Massena		X						1825-1940*

*Photostat copy of original.

PART FIVE

POWER DISTRIBUTION FOR CONSTRUCTION

ANALYSIS OF DESIGN AND ESTIMATE OF COST

Appendix A-2

ST. LAWRENCE RIVER PROJECT
CONSTRUCTION POWER

DESIGN ANALYSIS
POWER DISTRIBUTION FOR CONSTRUCTION

1. INTRODUCTION

The plan of distribution is based on a premise that 6,600 volt switches and switch gear will be available at Fort Peck for transfer to this work. If such equipment is not available when needed, it would be more economical to use a higher feeder voltage.

2. CONSTRUCTION

The construction proposed is as follows:

a. Transmission Line

H-frame, class 4, wood pole line, 110 k.v., single circuit, 8 disc insulators per string, 300 to 350 ft. spacing, two overhead ground wires.

b. Feeder Lines

Class 4 wood pole, 6.6 k.v., single circuit or double circuit as indicated, pin type insulators, average 250 ft. spacing, no ground wire.

c. Substation

Transformers: 3-8333 kva, single phase, 110,000/6,600 volt, self cooled.

Breakers: No 110 kv breakers as it is thought the power company will have breakers at its substation. There will be a breaker on each feeder. Lightning protection will be provided on both the high and low sides of the substation.

High and low tension buses will be of copper bars or tubing.

Switch boards and metering equipment will be provided. Batteries and charger for D.C. operation of switches. All equipment except transformers will be indoors.

The contractors must furnish their own step-down transformers (if any are required) and switches.

3. COST DATA

The cost estimate is based on the following data:

a. Transmission Line, 110,000 volts

Location	Length of Circuit in feet	Number of Circuits	Load KVA	Size of Conductor
Alcoa to Gov't substation	13,400	1	25,000	#2

b. Power Feeder Circuits 6,600 volts

From Substation to	Length of Circuit in feet	Number of Circuits	Load KVA	Size of Conductor
Powerhouse	20,500	2	7,500	500,000 c.m.
Grass River Lock	18,000	1	3,000	3/0
Long Sault Dam	10,300	1	5,500	3/0
Robinson Bay Lock	2,500	1	3,000	1/0
Seaway, N. Y.	5,200	1	2,500	4/0
Guard Gate Switch	7,300	1	3,500	3/0
From Guard Gate Switch to				
Guard Gate	4,000	1	1,500	#4
Massena Intake	14,200	1	2,000	1/0

ESTIMATE OF COST

CONSTRUCTION POWER

POWER DISTRIBUTION FOR CONSTRUCTION

1. TRANSMISSION LINE

Item	Designation	Unit	Quantity	Unit Price	Amount
1	Poles, 35', Class 4	ea.	2	$ 12.00	$ 24.00
2	" 40', " 4	ea.	10	15.00	150.00
3	" 45', " 4	ea.	32	20.00	640.00
4	" 50', " 4	ea.	12	30.00	360.00
5	" 60', " 4	ea.	2	42.00	84.00
6	Cross Arms and Fittings	Sets	35	24.00	840.00
7	Insulators, Suspension Type	ea.	840	1.75	1470.00
8	Hardware for Insulators	Sets	105	3.00	315.00
9	Guy Wire and Hardware	Sets	10	15.00	150.00
10	Wire, copper, #2 strand	lbs.	9000	.20	1800.00
11	Overhead Ground Wire and Fittings	Job	-----	-----	800.00
12	Cross Braces and Fittings	Sets	30	10.00	300.00
13	Bolts	Job	-----	-----	15.00
			Material		$ 6948.00
			Labor		3652.00
					$10600.00
	Engineering and Contingencies ± 18%				2000.00
			Total		$12600.00

2. DISTRIBUTION FEEDERS

a. Cost per pole, single circuit excluding conductors

Item	Designation	Unit	Quantity	Unit Price	Amount
1	Pole, 40', Class 4	ea.	1	$ 15.00	$ 15.00
2	Cross Arm, 3½" x 4½" x 9'	ea.	1	2.59	2.59
3	Bolt, 5/8" x 14"	ea.	1	.18	.18
4	Carriage Bolts	ea.	2	.05	.10
5	Washers, 2-1/4 x 2-1/4 x 3/16	ea.	4	.02	.08
6	Lag Screw	ea.	1	.05	.05
7	Insulator Pins	ea.	2	.55	1.10
8	Pole Top Pin	ea.	1	1.00	1.00
9	Insulators, Pin Type	ea.	3	.20	.60
10	Tie Wire	lb.	1	.22	.22
11	Guy Material	per pole	---	2.00	2.00
12	Cross Arm Braces	ea.	2	.18	.36
13	Lightning Arrester and Grounding	per pole	---	2.22	2.22
	Total cost per pole excluding conductor				$ 25.50

b. Cost per pole, double circuit, excluding conductor

Item	Designation	Unit	Quantity	Unit Price	Amount
1	Pole, 40', Class 4	ea.	1	$ 15.00	$ 15.00
2	Cross Arms, 3½" x 4½" x 9'	ea.	2	2.59	5.18
3	Bolt, 5/8 x 14"	ea.	2	.18	.36
4	Carriage Bolts	ea.	4	.05	.20
5	Washers, 2-1/4" x 2-1/4"x3/16"	ea.	8	.02	.16
6	Lag Screws	ea.	2	.05	.10
7	Insulator Pins	ea.	6	.55	3.30
8	Insulators, pintype	ea.	6	.20	1.20
9	Tie Wire	lb.	2	.22	.44
10	Guy Material	per pole	---	2.00	2.00
11	Cross Arm Braces	ea.	4	.18	.72
12	Lightning Arrester and Grounding	per pole	---	4.44	4.44
	Total cost per pole excluding conductor				$ 33.10

Note: The above unit prices include a 10% additon to allow for necessary double arming.

COST OF FEEDERS

Power House Line	
82 poles at $ 33.10	$ 2,714.20
189,420 lbs. of conductor at $ .20	37,884.00
Grass River Lock Line	
72 poles at $ 25.50	1,836.00
28,283 pounds of conductor at $ .20	5,656.60
Long Sault Dam Line	
41 poles at $ 25.50	1,045.50
6,216 pounds of conductor at $ .20	1,243.20
Robinson Bay Lock Line	
10 poles at $ 25.50	255.00
2,478 pounds of conductor at $ .20	495.60
Seaway, N.Y. Line	
21 poles at $ 25.50	535.50
10,285 pounds of conductor	2,057.00
Guard Gate Switch Line	
29 poles at $ 25.50	739.50
11,448 pounds of conductor at $ .20	2,289.60
Guard Gate Line	
16 poles at $ 25.50	408.00
1,561 pounds of conductor at $ .20	312.20
Massena Intake Line	
57 poles at $ 25.50	1,453.50
14,018 pounds of conductor at $ .20	2,803.60
Material	$ 61,729.00
Labor	33,671.00
	95,400.00
Engineering and Contingencies ± 18%	17,000.00
Total Cost of Distribution Feeders	$112,400.00

3. SUBSTATION

Building	$ 1,500.00
Transformers	50,000.00
*Switches and Switchgear	12,500.00
Miscellaneous	9,000.00
Material	$ 73,000.00
Labor	5,000.00
	78,000.00
Engineering and Contingencies ± 18%	14,000.00
Total Cost of Substation	$ 92,000.00

*This price is based on the Ft. Peck transfer price for this equipment.

Summary of Cost of Power Distribution

Transmission Line	$ 12,600.00
Distribution Feeders	112,400.00
Substation	92,000.00
Total	$217,000.00

PART SIX

House Document No. 978, 76th Congress, 3rd Session

House Document No. 153, 77th Congress, 1st Session

76th Congress
3d Session

HOUSE OF REPRESENTATIVES

Document
No. 978

DEVELOPMENT OF THE INTERNATIONAL RAPIDS SEC-
TION OF THE ST. LAWRENCE RIVER

MESSAGE

From
THE PRESIDENT OF THE UNITED STATES

Transmitting

A RECOMMENDATION FOR THE DEVELOPMENT OF THE INTERNATIONAL RAPIDS SECTION OF THE ST. LAWRENCE RIVER WHICH HAS BEEN RECOMMENDED BY THE FEDERAL POWER COMMISSION AND THE NATIONAL POWER POLICY COMMITTEE

October 17, 1940.--Referred to the Committee of the Whole House on the State of the Union and ordered to be printed

TO THE CONGRESS OF THE UNITED STATES:

The surveys of the Federal Power Commission and the National Power Policy Committee have convinced me that the development of the International Rapids section of the St. Lawrence River should be undertaken at the earliest possible date as a part of adequate provision to meet the continuing power requirements of the defense program in certain essential centers of war material production in the Northeastern States.

The potential power at this site is best adapted to meet the requirements of expansion in certain essential defense industries, including aluminum, magnesium, ferro-alloys, chemicals, etc. Actually, the Aluminum Co. of America has recently arranged for the import of 30,000 kilowatts of additional power from Canada to meet the pressing requirements of its existing plant located at the very site of the proposed St. Lawrence project and, I am reliably informed, is seeking additional supplies from across the border. Such imported supplies are, in effect, on an annual basis, subject to being withdrawn if required by the Canadian power market.

It is urgent that this project be undertaken at the present time, not only from the point of view of our own defense but also in terms of those of our neighbor, Canada. The Province of Ontario needs to be able to count upon the early availability of this power to meet its growing load. The project may, therefore, be considered as an essential part of the program of continental defense which is being actively worked out by representatives of the two peoples.

I am informed that if the potential power of the International Rapids is is to be available to carry the peak load of 1945, preliminary investigations, particularly engineering surveys of the site, including core borings, test pits, soil analyses, etc., must be undertaken immediately. I have therefore

allocated $1,000,000 of the special defense fund to the Federal Power Commission and Corps of Engineers, United States Army, for this preliminary work and have appointed a Committee of Four to advise me in planning the work and to cooperate with appropriate agencies of the Canadian Government. The members of this committee are Leland Olds, Chairman of the Federal Power Commission, as Chairman; A. A. Berle, Assistant Secretary of State; Brig. Gen. Thomas M. Robins, of the Board of Engineers for Rivers and Harbours, Corps of Engineers, United States Army; and Gerald V. Cruise, representative of the trustees of the Power Authority of the State of New York. I have directed the United States Corps of Engineers to begin the necessary investigations immediately.

The preliminary investigations which I have authorized involve no actual construction or commitment to construct. In taking this means of advising Congress of the surveys I am having made, I wish to make it clear that Congress will be kept advised of such further steps as may be necessary.

Franklin D. Roosevelt.

The White House, October 17, 1940.

77th Congress 1st Session	HOUSE OF REPRESENTATIVES	Document No. 153

TEXT OF AN AGREEMENT BETWEEN THE GOVERNMENTS OF THE UNITED STATES AND CANADA PERTAINING TO THE ST. LAWRENCE RIVER

MESSAGE

From

THE PRESIDENT OF THE UNITED STATES

Transmitting

THE TEXT OF AN AGREEMENT BETWEEN THE GOVERNMENT OF THE UNITED STATES AND THE GOVERNMENT OF CANADA PROVIDING FOR THE CONSTRUCTION OF DAMS AND POWER WORKS IN THE INTERNATIONAL RAPIDS SECTION OF THE ST. LAWRENCE RIVER, AND PROVIDING FOR COMPLETION OF THE ST. LAWRENCE DEEP WATERWAY.

March 21, 1941.--Referred to the Committee of the Whole House on the state of the Union and ordered to be printed.

TO THE CONGRESS OF THE UNITED STATES:

I transmit herewith for the information of the Congress the text of an agreement between the Government of the United States and the Government of Canada providing for the construction of dams and power works in the international rapids section of the St. Lawrence River; and providing for completion of the essential links in the Great Lakes-St.Lawrence Deep Waterway when the Governments of the United States and Canada agree that circumstances require it.

The terms of the agreement contemplate that it shall be made effective by concurrent legislation of the Canadian Parliament and of the Congress of the United States.

I expect to request introduction, in due course, of legislation designed to make this agreement effective.

Franklin D. Roosevelt.

The White House, March 21, 1941.

(Text of Agreement)

The President of the United States of America and His Majesty the King of Great Britain, Ireland and the British dominions beyond the Seas, Emperor of India, in respect of Canada, have decided to conclude an Agreement in relation to the utilization of the water in the Great Lakes-St. Lawrence Basin and to that end have named as their respective plenipotentiaries:

The President of the United States of America:

Jay Pierrepont Moffat,
Envoy Extraordinary and Minister Plenipotentiary of the United States of America to Canada;

Adolf Augustus Berle, Jr.,
Assistant Secretary of State;

Leland Olds,
Chairman of the Federal Power Commission;

His Majesty the King of Great Britain, Ireland and the British dominions beyond the Seas, Emperor of India, for Canada:

The Right Honourable W. L. Mackenzie King,
Prime Minister, President of the Privy Council and Secretary of State for External Affairs;

The Honourable Clarence D. Howe,
Minister of Munitions and Supply;

John E. Read,
Legal Adviser, Department of External Affairs;

Who, after having communicated to each other their full powers found in good and due form, have agreed upon the following Articles.

PRELIMINARY ARTICLE

For the purposes of the present Agreement, unless otherwise expressly provided, the expression:

(a) "Joint Board of Engineers" means the board appointed pursuant to an agreement between the Governments following the recommendation of the International Joint Commission, dated December 19, 1921;

(b) "Great Lakes System" means Lakes Superior, Michigan, Huron (Including Georgian Bay), Erie and Ontario, and the connecting waters, including Lake St. Clair;

(c) "St. Lawrence River" includes the river channels and the lakes forming parts of the river channels from the outlet of Lake Ontario to the sea;

(d) "International Section" means that part of the St. Lawrence River through which the international boundary line runs;

(e) "Canadian Section" means that part of the St. Lawrence River which lies wholly within Canada and which extends from the easterly limit of the International Section to Montreal Harbour.

(f) "International Rapids Sections" means that part of the International Section which extends from Chimney Point to the village of St. Regis;

(g) "Governments" means the Government of the United States of America and the Government of Canada;

(h) "countries" means the United States of America and Canada;

(i) "Special International Niagara Board" means the board appointed by the Governments in 1926 to ascertain and recommend ways and means to preserve the scenic beauty of the Niagara Falls;

(j) "deep waterway" means adequate provision for navigation requiring a controlling channel depth of 27 feet with a depth of 30 feet over lock sills, from the head of the Great Lakes to Montreal Harbour via the Great Lakes System and St. Lawrence River, in general accordance with the specifications

set forth in the Report of the Joint Board of Engineers, dated November 16, 1926.

ARTICLE 1

1. The Governments agree to establish and maintain a Great Lakes- St. Lawrence Basin Commission, hereinafter referred to as the Commission, consisting of not more than ten members of whom an equal number shall be appointed by each Government. The Duties of the Commission shall be:

(a) to prepare and to recommend plans and specifications for the construction of works in the International Rapids Section in accordance with and containing the features described in the Annex attached to and made part of this Agreement , with such modifications as may be agreed upon by the Governments;

(b) upon approval of the plans and specifications by the Governments, to prepare a schedule allocating the construction of the works in the International Rapids Section on such a basis that each Government shall construct the works within its own territory or an equivalent proportion of the works so approved;

(c) to approve all contracts entered into on behalf of either Government for the works in the International Rapids Section;

(d) to supervise the construction of the works and to submit reports to the Governments from time to time, and at least once each calendar year, on the progress of the works;

(e) upon satisfactory completion of the works, to certify to the Governments that they meet the plans and specifications drawn up by the Commission and approved by the Governments;

(f) to perform the other duties assigned to it in this Agreement.

2. The Commission shall have the authority to employ such person and to make such expenditures as may be necessary to carry out the duties set forth in this Agreement. It shall have the authority to avail itself of the services of such governmental agencies, officers and employees of either country as may be made available. The remuneration, general expenses and all other expenses of its members shall be regulated and paid by their respective Governments; and the other expenses of the Commission, except as provided for under Article III, paragraph (b) of this Agreement, shall be borne by the Governments in equal moieties.

3. The Governments agree to permit the entry into their respective countries, within areas immediately adjacent to the Niagara River and the International Section to be delimited by exchange of notes of personnel employed by the Commission or employed in the construction of the works, and to exempt such personnel from the operation of their immigration laws and regulations within the areas so delimited. In the event that the Commission, pursuant to the provisions of paragraph 1 (b) of this Article, allocates to either of the Governments the construction of works, any part of which is within the territory of the other Government, the latter Government shall make provision for the according, within the area in which such a part is situated, of such exemption from customs, excise and other imposts, federal, state and provincial, as may be reasonably practicable for the effective and economical prosecution of the work. Regulations providing for such exemptions may be settled by the Governments by exchange of notes.

4. The Governments shall, by exchange of notes, prescribe rules and regulations for the conduct of the Commission. They may by the same means extend or abridge its powers and duties and reduce or after reduction increase the number of members (provided that there must always be an equal number appointed by each Government and that the total number of members shall at no time exceed ten); and, upon completion of its duties, the Governments may terminate its existence.

ARTICLE II

The Government of Canada agrees:

(a) in accordance with the plans and specifications, prepared by the Commission and approved by the Governments, to construct the works in the International Rapids Section allocated to Canada by the Commission; and to operate and maintain or arrange for the operation and maintenance of the works situated in the territory of Canada;

(b) to complete, not later than December 31, 1948, the essential Canadian links in the deep waterway, including the necessary deepening of the new Welland Ship Canal and the construction of canals and other works to provide the necessary depth in the Canadian Section of the St. Lawrence River; provided that, if the continuance of war conditions or the requirements of defence justify a modification of the period within which such works shall be completed, the Governments may, by exchange of notes, arrange to defer or expedite their completion as circumstances may require.

ARTICLE III

The Government of the United States of America agrees:

(a) in accordance with the plans and specifications prepared by the Commission and approved by the Governments, to construct the works in the International Rapids Section allocated to the United States of America by the Commission; and to operate and maintain or arrange for the operation and maintenance of the works situated in the territory of the United States of America;

(b) to provide, as required by the progress of the works, funds for the construction, including design and supervision, of all works in the International Rapids Section except (1) machinery and equipment for the development of power, and (2) works required for rehabilitation on the Canadian side of the international boundary;

(c) not later than the date of completion of the essential Canadian links in the deep waterway, to complete the works allocated to it in the International Rapids Section and the works in the Great Lakes System above Lake Erie required to create essential links in the deep waterway.

ARTICLE IV

The Governments agree that:

(a) they may, in their respective territories, in conformity with the general plans for the project in the International Rapids Section, install or arrange for the installation of such machinery and equipment as may be desired for the development of power and at such time or times as may be most suitable in terms of their respective power requirements;

(b) in view of the need for co-orination of the plans and specifications prepared by the Commission for general works in the International Rapids

Section with plans for the development of power in the respective countries, the Commission may arrange for engineering services with any agency in either country which may be authorized to develop power in the International Rapids Section;

(c) except as modified by the provisions of Article VIII, paragraph (b) of this Agreement, each country shall be entitled to utilize one-half of the water available for power purposes in the International Rapids Section;

(d) during the construction and upon the completion of the works provided for in the International Rapids Section, the flow of water out of Lake Ontario into the St. Lawrence River shall be controlled and the flow of water through the International Section shall be regulated so that the navigable depths of water for shipping in the harbour of Montreal and throughout the navigable channel of the St. Lawrence River below Montreal, as such depths now exist or may hereafter be increased by dredging or other harbour or channel improvements, shall not be injuriously affected by the construction or operation of such works, and thé power developments in the Canadian Section of the St. Lawrence River shall not be adversely affected;

(e) upon the completion of the works provided for in the International Rapids Section, the power works shall be operated, initially, with the water level at the power houses held at a maximu elevation 238.0, sea level datum as defined in the Report of the Joint Board of Engineers for a test period of ten years or such shorter period as may be approved by any board or authority designated or established under the provisions of paragraph (f) of this Article; and, in the event that such board or authority considers that operation with the water level at the power houses held to a maximum elevation exceeding 238.0 would be practicable and could be made effective within the limitations prescribed by paragraphs (c) and (d) of this Article, the Governments may, be exchange of notes, authorize operation, subject to the provisions of this Article, and for such times and subject to such terms as may be prescribed in the notes, at a maximum elevation exceeding 238.0;

(f) the Governments may, by exchange of notes, make provision for giving effect to paragraphs (c), (d) and (e) of this Article;

(g) during the construction of the works provided for in the International Rapids Section, facilities for 14 ft. navigation in that Section shall be maintained.

ARTICLE V

The Governments agree that nothing done under the authority of this Agreement shall confer upon either of them proprietary rights, or legislative, administrative ro other jurisdiction, in the territory of the other, and that the works constructed under the provisions of this Agreement shall constitute a part of the territory of the country in which they are situated.

ARTICLE VI

The Governments agree that either of them may proceed at any time to construct, within its own territory and at its own cost, alternative canal and channel facilities for navigation in the International Section or in waters connecting the Great Lakes, and to utilize the water necessary for the operation of such facilities.

ARTICLE VII

The High Contracting Parties agree that the rights of navigation accorded under the provisions of existing treaties between the United States of America and His Majesty shall be maintained notwithstanding the provisions for termination contained in any of such treaties, and declare that these treaties confer upon the citizens or subjects and upon the ships, vessels and boats of each High Contracting Party, rights of navigation in the St. Lawrence River, and the Great Lakes System, including the canals now existing or which may hereafter be constructed.

ARTICLE VIII

The Governments, recognizing their common interest in the preservation of the levels of the Great Lakes System, agree that:

(a) each Government in its own territory shall measure the quantities of water which at any point are diverted from or added to the Great Lakes System, and shall place such measurements on record with the other Government semi-annually;

(b) in the event of diversions being made into the Great Lakes System from other watersheds lying wholly within the borders of either country, the exclusive rights to the use of waters which are determined by the Governments to be equivalent in quantity to any waters so diverted shall, notwithstanding the provisions of Article IV, paragraph (c) of this Agreement, be vested in the country diverting such waters, and the quantity of water so diverted shall be at all times available to that country for use for power below the point of entry, so long as it constitutes a part of boundary waters;

(c) if any diversion of water from the Great Lakes System or the International Section, other or greater in amount than diversions permitted in either of the countries on January 1 1940 is authorized, the Government of such country agrees to give immediate consideration to any representations respecting the matter which the other Government may make; if it is impossible otherwise to reach a satisfactory settlement, the Government of the country in which the diversion of water has been authorized agrees, on the request of the other Government, to submit the matter to an arbitral tribunal which shall be empowered to direct such compensatory or remedial measured as it may deem just and equitable; the arbitral tribunal shall consist of three members, one to be appointed by each of the Governments, and the third, who will be the chairman, to be selected by the Governments;

(d) the Commission shall report upon the desirability of works for compensation and regulation in the Great Lakes System, and, upon the approval by the Governments of any such works, shall prepare plans and specifications for their construction and recommend to the Governments an equitable allocation of their cost; the Governments shall make arrangements by exchange of notes for the construction of such works as they may agree upon.

ARTICLE IX

The Governments, recognizing their primary obligation to preserve and enhance the scenic beauty of the Niagara Falls and River, and consistent with that obligation, their common interest in providing for the most beneficial use of the waters of that River, as envisaged in the Final Report of the Special International Niagara Board, agree that:

(a) the Commission shall prepare and submit to the Governments plans and specifications for works in the Niagara River designed to distribute and control the waters thereof, to prevent erosion and to ensure at all seasons unbroken crest lines on both the American Falls and the Canadian Falls and to preserve and enhance their scenic beauty, taking into account the recommendations of the Special International Niagara Board; the Governments may make arrangements by exchange of notes for the construction of such works in the Niagara River as they may agree upon, including provision for temporary diversions fo the waters of the Niagara River for the purpose of facilitating construction of the works; the cost of such works in the Niagara River shall be borne by the Governments in equal moieties;

(b) upon the completion of the works authorized in this Article, diversions of the waters of the Niagara River above the Falls from the natural course and stream thereof additional to the amounts specified in Article 5 of the Boundary Waters Treaty of 1909 may be authorized and permitted by the Government to the extent and in the manner hereinafter provided:

(1) the United States may authorize and permit additional diversion within the State of New York of the waters of the River above the Falls for power purposes, in excess of the amount specified in Article 5 of the Boundary Waters Treaty of 1909, not to exceed in the aggregate a daily diversion at the rate of five thousand cubic feet of water per second;

(2) Canada may authorize and permit additional diversion within the Province of Ontario of the waters of the River above the Falls for power purposes, in excess of the amount specified in Article 5 of the Boundary Waters Treaty of 1909, not to exceed in the aggregate a daily diversion at the rate of five thousand cubic feet of water per second;

(c) upon completion of the works authorized in this Article, the Commission shall proceed immediately to test such works under a wide range of conditions, and to report and certify to the Governments the effect of such works, and to make recommendations respecting diversions of water from Lake Erie and the Niagara River, with particular reference to (1) the perpetual preservation of the scenic beauty of the Falls and Rapids, (2) the requirements of navigation in the Great Lakes System, and (3) the efficient utilization and equitable apportionment of such waters as may be available for power purposes; on the basis of the Commission's reports and recommendations, the Governments may by exchange of notes and concurrent legislation determine the methods by which these purposes may be attained.

ARTICLE X

The Governments agree that:

(a) each Government undertakes to make provision for the disposition of claims and for the satisfaction of any valid claims arising out of damage or injury to persons or property occurring in the territory of the other in the course of and in connection with construction by such Government of any of the works authorized or provided for by this Agreement.

(b) each Government is hereby released from responsibility for any damage or injury to persons or property in the territory of the other which may be caused by any action authorized or provided for by this Agreement, other than damage or injury covered by the provisions of paragraph (a) of this Article;

(c) each Government will assume the responsibility for and the expense involved in the acquisition of any lands or interests in land in its own

territory which may be necessary to give effect to the provisions of this Agreement.

ARTICLE XI

This Agreement shall be subject to approval by the Congress of the United States of America and the Parliament of Canada. Following such approval it shall be proclaimed by the President of the United States of America and ratified by His Majesty the King of Great Britain, Ireland and the British dominions beyond the Seas, Emperor of India in respect of Canada. It shall enter into force on the day of the exchange of the instrument of ratification and a copy of the proclamation, which shall take place at Washington.

In witness whereof the respective plenipotentiaries have signed this Agreement in duplicate and have hereunto affixed their seals.

Done at Ottawa, the nineteenth day of March, in the year of our Lord one thousand nine hundred and forty-one.

(Seal) Jay Pierrepont Moffat
(Seal) Adolf A. Berle, Jr.
(Seal) Leland Olds
(Seal) W. L. Mackenzie King
(Seal) C. D. Howe
(Seal) John E. Read

ANNEX

Controlled Single Stage Project (238-242)

For Works in the International Rapids Section

(See Article 1, Paragraph 1 (a))

The main features of the Controlled Single Stage Project (238-242), described in detail with cost estimates in the report of the Temporary Great Lakes-St. Lawrence Basin Committees dated January 3, 1941, are as follows:

(1) A control dam in the vicinity of Iroquois Point.

(2) A dam in the Long Sault Rapids at the head of Branhart Island and two power houses, one on either side of the international boundary, at the foot of Barnhart Island.

(3) A side canal, with one lock on the United States mainland to carry navigation around the control dam and a side canal, with one guard gate and two locks, on the United States mainland south of Barnhart Island to carry navigation from above the main Long Sault Dam to the river south of Cornwall Island. All locks to provide 30ft. depth of water on the mitre sills and to be of the general dimensions of those of the Welland Ship Canal. All navigation channels to be excavated to 27ft. depth.

(4) Dykes, where necessary, on the United States and Canadian sides of the international boundary, to retain the pool level above the Long Sault Dam.

(5) Channel enlargement from the head of Galop Island to below Lotus Island designed to give a maximum velocity in the navigation channel south of Galop Island not exceeding four feet per second at any time

(6) Channel enlargement between Lotus Island and the control dam and from above Point Three Points to below Ogden Island designed to give a maximum mean velocity in any cross-section not exceeding two and one-quarter feet per second with the flow and at the stage to be permitted on the 1st of January of any year, under regulation of outflow and levels of Lake Ontario.

(7) The necessary railroad and highway modifications on either side of the international boundary.

(8) The necessary works to permit the continuance of 14 ft. navigation on the Canadian side around the control dam and from the pool above the Long Sault Dam to connect with the existing Cornwall Canal.

(9) The rehabilitation of the towns of Iroquois and Morrisburg, Ontario.

All the works in the pool below the control dam shall be designed to provide for full Lake Ontario level but initially the pool shall be operated at maximum elevation 238.0.

ST. LAWRENCE RIVER PROJECT

FINAL REPORT

1942

DOCUMENTS Room

SEISMIC EXPLORATION

1940 & 1941

UNIVERSITY OF ... THE PROPERTY OF ... LIBRARY

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX B-2

ST. LAWRENCE RIVER

PROJECT

* * * * *

FINAL REPORT

1942

SEISMIC EXPLORATION

1940 & 1941

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office - Massena, New York

July , 1942

APPENDIX B-2

St. Lawrence River Project
Seismic Exploration 1940 and 1941

CONTENTS

TABLES

PLATES

APPENDIX A
LOCATION OF SEISMIC EXPLORATION

ST. LAWRENCE RIVER PROJECT
SEISMIC EXPLORATION 1940 AND 1941

I INTRODUCTION

1. Purpose of Report. - The purpose of this report is to discuss the results and to describe in detail the seismic investigations made between November 1940 and October 1941 on the St. Lawrence River Project. The seismic investigations were conducted by the St. Lawrence River District of the U. S. Corps of Engineers with an office located at Massena, New York.

2. Description of Project. - The St. Lawrence River Project is located in what is known as the International Rapids Section of the St. Lawrence River and extends from Ogdensburg, New York to a few miles downstream from Cornwall, Ontario, as shown on Plate I. The main features of the controlled single-stage project are (1) a control dam at Iroquois Point, (2) a dam in the Long Sault Rapids between Barnhart Island and the U. S. mainland, (3) two powerhouses, one on either side of the International Boundary, at the foot of Barnhart Island, (4) a side canal with one lock on the U. S. mainland to carry navigation around the control dam, (5) a side canal with 2 locks on the U. S. mainland to carry navigation around the main Long Sault Dam, (6) channels and cuts to produce suitable navigation and hydraulic conditions, (7) all required dikes, railroads and highways, (8) necessary works to permit usual operation of the present navigation canal in Canada, and (9) necessary control structure to permit the continual operation of the Massena Power Canal.

3. Regional Geology. - The St. Lawrence valley is a region of low relief which has been greatly modified by glaciation and marine invasion. The area of the valley in which seismic investigations have been conducted is underlain by sedimentary rocks, mainly dolomite and limestone of Lower Ordovician age. In general glacial action has removed the residual, soft, weathered rock, leaving a generally smooth, undulating, hard rock surface of low relief broken by occasional valleys, ridges, and faults. The overburden consists of deposits of variable glacial till in the form of elongate ridges and deposits of clays, silts, and uniform sands in the valleys between the till ridges.

II FIELD EXPLORATION

4. Exploration Prior to October 1940. - Prior to October 1940, sufficient studies and investigations had been made to determine the plan of the project and the general location of each feature. The exploration at the site of each structure, except at the Long Sault Dam and powerhouse sites consisted of a very few drill holes from which the general rock elevations could be determined. At the Long Sault Dam and powerhouse sites relatively more exploration had been completed than at other sites.

5. Exploration October 1940 To January 1942. - Since October 1940, the exploration completed through January 1942 has consisted of 1486 drill holes, 930 test pits and auger holes, 822 probings in soft overburden, 457 seismic lines and single determinations, and extensive geological reconnaissance. Complete data on all exploration are on file in the district office.

6. At the outset of the present exploratory program it was recognized that subsurface conditions were favorable to the seismic method of investigation and that the interface between the hard rock and the overburden could

be determined with fair accuracy, also that some success in the classification of the overburden might be achieved.

7. To obtain information regarding the elevation of bedrock for the preliminary design and the definite location of structures, a program of drilling and siesmic investigations were conducted. The overburden conditions were determined by drilling and to some extent by seismic explorations. Extensive tests were conducted at sites where very little information was available to determine general rock and soil conditions for preliminary layouts. The results of the seismic investigations were used to plan a limited drilling program to obtain more detailed information. At sites where sufficient data was available for laying out a drilling program, only a few seismic determinations were made. In general, the seismic method was used to obtain data between the drill holes. In this manner, the drilling program was kept to a minimum.

8. The locations and results of all seismic lines and single shot determinations are shown on Plates AI to AXXI, inclusive of Appendix A to this report. Locations where the results were not considered sufficiently accurate to be of value have been omitted from the plates. Table I lists each line fired, the transverse mercator coordinates of the center point, the azimuth of the line, the general location of the line as to site and the plate on which the line is plotted.

III ORGANIZATION

9. <u>General</u>. - Seismic exploration was originally organized under the Soils and Foundation Section, which provided the supplies and all personnel. At a later date the operations Division supplied and conducted all phases of the field operations while the Soils and Foundation Section continued to handle the technical aspects of the work. Field work was begun on November 13, 1940, at which time Mr. E. R. Shepard, Office of the Chief of Engineers, organized a field party and remained with it until November 19, after which time Dr. A. E. Wood, Associate Geologist of the Binghamton District, assumed technical direction of the work and personally analyzed and interpreted most of the field data until early in February, 1941, when he was recalled to the Binghamton District. He was assisted in his interpretations by W. A. Wells of the Massena Office, who thereafter interpreted the field data during Mr. Shepard's absence. On February 25, 1941, Mr. Shepard returned to Massena and in the following ten days reviewed all of the data that had been collected up to that time.

10. Because frost in the ground began to seriously interfere with the accuracy of the interpretations, field work was suspended from March 3 until April 28, after which date it continued until October 17, 1941. From May 12, 1941, until completion of the work, with minor interruptions, Mr. Shepard gave his entire time to interpretation and analysis of field data and to the development of special apparatus and technique for exploration under water.

11. Following are the names of several operators who were responsible for the field work, together with the periods during which each served:

K. J. Bassett, Binghamton District, November 13, 1940 to Nov. 26, 1940.
Paul Shea, Providence District, Nov. 27, 1940, to Dec. 23, 1940.
K. J. Bassett, Binghamton District, Dec. 27, 1940, to March 3, 1941.
K. J. Bassett, " " , April 28, 1941, to May 10, 1941.
M. J. Verville, Massena District, May 12, 1941, to June 2, 1941.
L. T. Abele, South Atlantic Division, June 3, 1941, to July 24, 1941.
Walter Wright, Massena District, July 25, 1941, to Sept. 16, 1941.
Walter Wright, " " , Oct. 13, 1941, to Oct. 17, 1941.

IV THEORY OF SEISMIC METHOD

12. Principles Involved. - A comprehensive discussion of the principles involed in seismic exploration will not be given as the subject is adequately treated in voluminous literature. A brief description of the theory is necessary, however, if the significance of the data here presented is to be understood.

13. The seismic method of exploration is based on the fact that the velocity of wage propagation in the earth's crust differs greatly in different substances. Granular and plastic materials such as sand, clay, and gravel transmit wave disturbances at velocities of roughly 800 to 8,000 feet per second, while rigid rack transmits such disturbances at 10,000 to 20,000 feet per second. This wide range in velocities in different kinds of soils and rocks is dependent on their elastic properties, a factor closely related to their rigidity and hardness. Many factors such as moisture, texture, compaction, void space, cementation, and homogeneity enter into the problem and must be reckoned with in analyzing any particular condition.

14. To obtain data from which the velocities of wave propagation and depths of various materials can be determined, detectors (Usually three) are placed on the ground surface and charges of dynamite are exploded at various distances from the detectors. The time interval for the wave to travel from the charge to the detector is photographically recorded with an oscillograph to which the detectors and the detonating circuit are electrically connected. A time scale, made by an electrically driven tuning fork, is recorded on the oscillograph film. From the film records the time interval of the first arrival of wave travel from each shot to each of the detectors is read and the data are plotted to the form of a time-distance graph, as shown on Plate II.

15. In a homogeneous material the time-distance relation will be a straight line through the origin. This is evident from the fact that in such a medium the velocity of wave propagation is constant, or the time of travel is proportional to the shooting distance. It is also evident that the slope of such a graph is a measure of the velocity in the medium.

16. When a layer of homogeneous soil is underlain by one through which waves travel at a higher velocity, such as that designated as clay (See Plate II), there will be a critical distance, OF, for which the time of travel through the upper medium is just equal to the time of travel over the longer path which penetrates the lower medium. At this critical distance there will be a break in the time-distance graph to a different slope, CD, which represents the velocity of wave propagation in the second medium. In like manner when the critical shooting distance, OG, is passed, the first arrivals will be through the high-velocity rock and the time-distance graph will assume the new trend, DW, the slope of which determines the velocity in the rock stratum. From the ordinates OA and AB on the time axis and the velocities indicated by the slopes of the several elements of the graph, it is possible to calculate the thickness of each stratum of overburden.

V EQUIPMENT

17. General. - The seismograph used throughout the investigation was one of a type designed by E. R. Shepard of the Office of the Chief of Engineers, and leased from the Binghamton U. S. Engineer District, This apparatus consisted of one or more detectors or geophones and an oscillograph recorder. A photograph of the instrument and detector is shown on Plate III.

18. Special Equipment. - To satisfactorily conduct subaqueous exploration, it was necessary to waterproof the detectors and so mount them that they would assume a vertical position when lowered to the bed of the river. A waterproof housing for each detector was made consisting of a 3½-inch steel pipe 10 inches long with the lower end closed with a steel plate and the upper end closed with a cap containing a 3/4-inch pipe nipple. A detector, to which a pair of rubber covered leads about 30 feet in length were attached, was placed in the housing and held tightly with cotton waste packed around the sides and over the terminals. The leads passed through the nipple. It is of course important that the detector rest firmly on the bottom of the housing.

19. Two methods were used to keep the detectors in a vertical position on the bed of the river. For depths not in excess of 10 feet, the detectors were mounted as shown on Plate IV. Where the water was more than 10 feet deep the detector assembly shown on Plate V was used. The detector in the waterproof housing was suspended from the apex of a heavy iron tripod. When lowered into position the detector assumed a vertical position regardless of the configuration of the river bed and although the detector did not rest directly on the bottom, it received the shock from the explosion through the legs of the tripod and the suspension wire.

VI PROCEDURE OF FIELD WORK

20. General. - The seismic field party consisted of an operator, who was also party chief in complete charge of all phases of the field work; and six helpers, one an authorized powder or dynamite man. A light truck served as transportation for the party and equipment. The seismic operator was responsible for recording all information valuable to the interpreter of the data or anyone else who may be interested in a particular line. In a field notebook were recorded the number of each shot, remarks regarding each shot and distance of each of the detectors from each shot. The operator also made a small sketch showing the location of the line with reference to local features to aid surveyors in locating the line, and recorded weather conditions, ground conditions, depth of frost, and any other information which may aid in the interpretation of the data. All film records were developed by the Burkett Studio of Massena and were always available for interpretation on the morning following that on which they were shot. All field notes and seismic film are on file in the district office.

21. Land Work. - The general locations of the desired seismic lines on land were plotted on maps in the office. The operator then located himself in the field by the topography and landmarks shown on the map, and laid out the line along a contour. An effort was made to stay on one type of overburden. The half of the line extending down river or toward the river from the center was called "Ahead" and the half extending up river or away from the river was called "Back." In ordinary field procedure three detectors were placed on the ground in a line at intervals of 40 feet and connected to the oscillograph with lead wires. Dynamite charges varying from ½ to 4½ sticks were buried to a depth of about 3 feet and were then fired successively and at increasing distances along the detector line, beginning at 10 feet from the center detector and extending the shooting distance by intervals of about 50 feet to such lengths as was required. A shooting distance of three or four times the depth to which information was desired was usually necessary. The charges were fired by means of a detonating circuit which is controlled by the oscillograph. Prior to firing the shots relative elevations of shot and detector points to the center of the line were taken with a hand level. The location and elevation of the center and the azimuth of each line was determined by field surveys.

22. Work in Quiet Water. - The need for information on the character and depth of overburden in the bed of the river in the vicinity of Chimney Island and Galop Island (See Plates AI, AII, and AIII of Appendix A), necessitated the development of the special apparatus described in paragraphs 18 and 19 and a revised testing technique.

23. The laying out of a line was accomplished by a float or marker line constructed by attaching wooden blocks at designated points on a 3/8" hemp rope approximately 600 feet long.

Measured from the center of the line, floats were attached at the following points: 0, 10, 40, 80, 130, 180, and 230 feet in both directions. The center float and those at 40 feet either side of the center marked the detector positions, while the other blocks marked the shot points as on a normal land line.

24. One end of the float line was anchored on the bed of the river approximately 300 feet upstream from the center of the seismic line along which information was desired. The line was then allowed to float downstream until it assumed a stable position. Where the current was not strong enough to stretch the line it was necessary to anchor both ends after maneuvering it into the desired position. In some instances it was necessary to anchor the center of the line also to prevent it from drifting with the wind or current. It was usually necessary to attach buoys to the line at anchor points to keep the markers afloat. Empty oil cans of 2 or 5 gallon capacity were found satisfactory for this purpose. Soundings were taken at each shot and detector positions to ascertain the variation in elevation along the line. Observers on shore determined the position of each line and the elevation of the water surface.

25. After stretching and anchoring the float line, three detectors were placed with the special equipment described in paragraphs 18 and 19 and shown on Plates IV and V. For depths of water not in excess of 10 feet a pipe or rod was driven at each detector position and the detector assembly shown on Plate IV was lashed to the pipe or rod in a vertical position. Where the water was more than 10 feet deep, the detector assembly shown on Plate V was lowered to the river bottom with a rope after the nipple was sealed against entrance of water. A boat containing the receiving apparatus was anchored about 50 feet from the center detector and the three pairs of leads used in land work were connected to the auxiliary leads attached to the detectors. The charges of dynamite were lowered in position using a rock tied to a piece of flagging or burlap to act as a sinker. Connections were made and the charges were fired as in land practice. Where working in swift or deep water, allowance was made for the probable drift of the charge.

26. Work in Channel at Long Sault Dam Site. - A method differing from those just described was developed for the purpose of exploring in the river channel at the Long Sault Dam site where exceptionally swift water made it impossible to place detectors in water or to satisfactorily maneuver boats. Plate VI illustrates both the arrangement of apparatus and method of analysis. The detectors and the oscillograph were placed on shore close to the region to be explored. The detectors were placed near a drill hole or a seismic line where the depth to rock was known. The velocity of the waves in the overburden under the detectors was determined by the usual land procedure. Single disseminated charges of dynamite were placed with a float or boat and fired by means of the usual detonating system.

27. One group of shots, SS3674 to SS3680, inclusive, were placed and fired while the detectors were at drill hole D-1059. The firing line and a heavy sinker were attached to the charge and a boat then

carried the charge out in the river and dropped it. The location of the charge when dropped was determined by observations made on land by two observers with transits. Soundings were taken at the time of dropping the charge if possible, otherwise the approximate elevation of the river bottom was obtained from a map showing the sub-aqueous contours in the vicinity. The application of this method was limited owing to the difficulty of handling the shot line in swift water.

28. The other group of single shots, S 415 to S 418, inclusive, were placed and fired while the detectors were 120 feet from drill hole D-1364 and at the center of line S 414 on the shoal in the channel. The firing line and a heavy sinker were attached to the charge and the charge was then placed on a float made of two oil drums lashed together. The float attached to a cable was allowed to drift downstream with the current but was controlled by a winch mounted on the shoal. To keep the firing line from breaking it was threaded through rings on the cable. When the float was at the desired location, a boat came alongside and the charge was released into the river. The location of the charge was determined by the observers on shore. The float was then pulled 50 to 100 feet upstream and the shot fired. The depth of the river at the location of the shot was determined by actual soundings or from the map showing the subaqueous contours.

VII ANALYSIS OF DATA

29. General. - The analysis of the seismic data consisted of reading the film, plotting the time-distance graphs, and computing the depths to rock in the manner described in the article "The Seismic Method of Exploration Applied to Construction Projects" by E. R. Shepard, the Military Engineer, September-October, 1939. A typical time-distance graph is shown on Plate VII, which illustrates the manner of plotting and the analysis of the data. All field notes, film, and time-distance graphs and depth computations are on file in the district office.

30. Determination of Elevation of Bedrock by Two-Way Shooting. In the determination of the elevation of bedrock by the seismic method, the main problem is the determination of the true velocities in the media as these velocities are used in the computations. Because of the discrepancies between the true and apparent velocities several shots from opposite directions on a line through the detectors were made to obtain accurate results. The discrepancies are a result of sloping interfaces between different strata and velocity irregularities in the upper-soil, this latter cause being the most prevalent. When shooting up dip along a sloping interface the apparent velocity in the deeper medium is higher than the true velocity and when shooting down dip the apparent velocity is less than the true velocity. Variations in moisture content, compaction, and other physical properties of soil immediately beneath the detectors gave rise to similar effects produced by sloping interfaces. In order to obtain the most accurate results an experienced interpreter who thoroughly understood the theory of the seismic computations and also the overburden conditions as they existed in the field made the choice of overburden velocities and method of calculation.

31. A typical time-distance graph is shown on Plate VII which illustrates the manner used for plotting and analyzing the date from land lines or lines in quiet water. With three detectors spaced at 40-foot intervals along the shot line, three points along the graph were obtained from each shot as shown. Shots ahead of the center are shown by open characters, and shots back of the center are shown by corresponding closed characters. A study of the graph will show that for shooting distances up to 15 feet, first arrivals were through the upper-soil, in which the velocity was 1,430 feet per second. For shooting distances from 15 to 250 feet first arrivals were through a compact material in which the velocity of 6200 feet per second was determined. For shooting distances greater than 250 feet, the arrival times were shorter by way of the deep rock than through the overburden. The apparent velocity in rock, V_u, when shooting from the "Ahead" end of the line or up dip is just twice as great as the apparent velocity, V_d, when shooting from the "Back" end of the line or down dip. The true velocity in the rock, V_r, was determined by taking the harmonic mean of the apparent velocities and was found to be 16,400 feet per second.

32. After the velocities have been determined the actual computations for the depth to rock are relatively simple. The formulas used to determine the depth to rock were developed by Ewing, Crary, and Rutherford and are derived in the article "The Seismic Method of Exploration Applied to Construction Projects", E. R. Shepard, The Military Engineer, September-October 1939. These formulas in the forms most frequently used are as follows:

$$H_1 = \frac{T_1 V_1}{2 \cos \alpha}$$

$$H_2 = \frac{T_2 V_2}{2 \cos \beta_2} - \frac{H_1 \cos \beta_1 V_2}{V_1 \cos \beta_2}$$

$$H_3 = \frac{T_3 V_3}{2 \cos \gamma_3} - \frac{H_1 \cos \gamma_1 V_3}{V_1 \cos \gamma_3} - \frac{H_2 \cos \gamma_2 V_3}{V_1 \cos \gamma_3}$$

where

H_1, H_2, H_3 = Thickness of various layers

V_1, V_2, V_3 = Wave velocities in corresponding layers

T_1, T_2, T_3 = Total travel times for paths through corresponding layers.

α, β, γ = Angles of refraction

$\sin \alpha = \frac{V_1}{V_2}$; $\sin \beta_1 = \frac{V_1}{V_3}$; $\sin \beta_2 = \frac{V_2}{V_3}$

$\sin \gamma_1 = \frac{V_1}{V_4}$; $\sin \gamma_2 = \frac{V_2}{V_4}$; $\sin \gamma_3 = \frac{V_3}{V_4}$

In some instances it was possible to use a simpler form of computation which amounts to a short cut over the above standard method. This shorter method of interpretation is described and its applicability discussed in the article "Application of the Seismic Refraction Method of Subsurface Exploration to Flood Control Projects", E. R. Shepard and A. E. Wood, American Institute of Mining and Mettallurgical Engineers, Technical Publication No. 1219, June 1940.

33. On Plate VII the elevation of bedrock at the center of the line was computed as shown using the velocities previously determined. The method used in the computations of the rock elevation for this particular line was the short cut method referred to above. From the computations it will be seen that the depth of the upper-soil layer, H_1, in which the velocity of wave propagation was 1,430 feet per second, is 7.4 feet. T_1 in this instance is the point of intersection of V_2 on the time axis or 1.6. H_2 (ahead) or the thickness of the glacial till under the ahead end of the line is computed to be 89.5 feet. T_2 in this case is the difference between the intercepts of V_3 (ahead) and V_2 on the time axis and equal to 5.34. Similarly H_2 for the back half of the line was computed to be 77.5 feet. The total depth of overburden ahead and back equals 96.9 and 84.9 feet respectively. The depth at the center is assumed to be the average of these two values or 90.9 feet. Theoretically any depth determination was arrived at by taking one-half the sum of the depths at the shot point and the detector or receiving point, neither of which depth was known. The recorded depth for any line was the average of the mean or normal depths so determined for the two ends of the line. Because of the prevalent variation between the apparent and true velocities in most of the areas investigated, it was believed unwise to attempt to determine slopes in the rock surface from apparent velocities or to predict multiple rock elevations along a shooting line and only one rock elevation on each line has been recorded in the final analysis of the data. The recorded elevation was designated as that at the center of the line. However, in preparing rock contour maps for an area the general rock trends as determined by the seismic lines have been of great assistance.

34. <u>Determination of Overburden Conditions</u>. - In most locations considerable success has been attained in classifying the overburden with respect to hardness and compaction as well as determining the elevation of rock. In areas where the characteristics of the overburden were generally known the seismic data were beneficial in determining the depths of the individual strata. The seismic results have aided considerably in the studies made regarding overburden conditions at structure sites and where excavations will be made for proposed hydraulic cuts and navigation channels.

35. From correlation between drill holes and seismic lines over the entire project, the range of velocities for the various types of overburden

have been determined. Thus it was generally true that in areas investigated velocities of 1,000 to 2,000 feet per second indicated very loose material, velocities of 4,500 to 5,000 feet per second usually were indicative of relatively soft material such as silt or clay, however, in some instances such velocities did indicate fairly loose deposits of glacial till, and velocities in excess of 5,000 feet per second usually indicated the presence of compact glacial tills. One exception to the last statement was detected at the eastern end of Barnhart Island where velocities from 6,000 to 8,000 feet per second were obtained in a deposit of stratified partially water-laid sands and gravels.

36. A reference to Table II will show that a large majority of the sites investigated, two types of overburden exist, as indicated on Plate VII. On the till ridges, velocities usually ranged from 1,000 to 2,000 feet per second, to depths of from 5 to 8 feet. This zone of loose material is indicated by the steep portion of the graph through the origin. Beneath this zone of loose material, the velocity usually changed to a much higher value, the magnitude of which depended on the character of the material. Along the margin of the river and also in the bed of the river, overburden of a single velocity was often found, the graphs obtained being similar to that shown on Plate VIII. In some locations, three types of overburden were found, as shown on Plate IX, The soil profile as indicated by such graphs may not always be recognized in drill logs or by visual inspection, as velocity characteristics are determined by the depth of frost action, compaction, and other factors which may not appear from sampling. However, it is generally believed that velocities afford a fair index of the labor involved in excavating overburden.

37. <u>Determination of Rock Elevation in Channel at Long Sault Dam Site</u>.- The method of analyzing the data obtained in the channels at the Long Sault Dam site differed from the usual method of analysis as the knowns and unknowns were different and the necessary assumption more radical. On Plate VI is shown a diagrammatic sketch of the method used to explore the channel and also a typical time distance graph to aid in the explanation of the method of analysis described below.

38. The only information obtained from the film record was the total time, T, which elapsed from the shot instant to the arrival of the shock at the detector, D. This total time, T, was made up of t_1, the time of transit through the overburden at the shot S, t_2 the time of transit through the rock from B to C, and t_3, the time of transit through the overburden CD. The value T was plotted on the time-distance coordinates at Q for the shooting distance OR, as shown, As the velocity in the rock was known from previous tests on shore, it was possible to draw the line QM which gives PM or t_2 as the time of transit in the rock, Also the depth CD was known from boring and seismic records and the velocity V_1 of wave propagation in the overburden from seismic tests, it was possible to lay off ON as t_3, the time of transit in the overburden at CD. This left MN, or t_1, as the time consumed in the overburden SB. To compute the depth H, or SB, it was necessary to assume the same overburden velocity there as at CD.

39. The results as obtained from shooting in exceptionally swift water have certain probable inherent inaccuracies which should be considered. The assumption that the overburden and rock velocities were the same at SB as at CD could be in error, however, any error in this assumption would only be proportional to velocity variations from place to place in the overburden or rock. A more likely source of error would probably be that in obtaining the true value of t_1. Where the depths to be measured are not great, the value of t_1 would be small in comparison with T, and any errors in determining t_2 and t_3 will be carried into t_1 and may seriously affect its accuracy. Another source of error which should be kept to the minimum possible is in the determination of the shooting distance. With the velocity ratio of 17000/5000 as shown, an error of 3.4 feet in the shooting distance would result in a 1-foot error in H_1. The accuracy of the rock determination also depended on the accuracy of the sounding of the river bottom. For large values of H_1 these errors are relatively small but where attempts are made to measure shallow overburdens in this manner the indications would probably be entirely misleading.

VIII - VALIDITY OF RESULTS

40. General. - The validity of the seismic results is believed to be very good in general with the exception of lines shot which were affected by frost, artificial fill, or where the depth of overburden in the Point Rockway Canal area was very shallow. The lines fired in shallow water are believed to be reliable but the results of lines shot in deep water and shots fired in the exceptionally swift water are questionable because the location of shots doubtful. Any appreciable error in the shot distance causes an appreciable error in the rock elevation. Table III is a tabulation of seismic and drilling data at all locations where a drill hole was close enough to the center of the seismic line to make a comparison of the data significant. In practically all locations listed in Table III, the difference in depths of overburden as determined by the two methods are within the limit of the relief in the rock surface. The results of all the seismic lines are given in Table II which has been arranged as to location. Lines on which the data were insufficient to justify a depth calculation and lines on which the calculated depths are uncertain are so indicated in Table I and these lines have been omitted from the location maps (See Plates AI to AXXI, inclusive of Appendix A of this report).

41. The seismic method of exploration heretofore has been considered primarily or reconnaissance investigations and has not been used for making more detailed analysis. In the case of the St. Lawrence River Project, the information obtained by seismic investigation has been used more broadly than is generally the case. All important structure sites have been explored by drilling with a small number of seismic lines to supplement the drilling program. However, all proposed cuts and channels with the exception of the canals, have been explored primarily by seismic methods with the addition of a few drill holes to determine overburden conditions and to verify seismic

results where bedrock occurred above or near excavation grade. Consequently the results of seismic exploration have been used to a large extent as the basis for quantity and cost calculations.

42. Point Rockway Canal. - In one area in the Point Rockway Canal difficulty was encountered in properly identifying hard rock which was within a few feet of the ground surface. The graph shown on Plate X is typical of several obtained in the canal area where the drilling disclosed hard rock within 1 to 5 feet of the surface. In the original analysis of the data, the intermediate material, indicated by the 5,000 foot per second limb of the graph, was believed to be clay or till, although the irregularity of the data threw some doubt on this interpretation, and indicated the possible presence of a zone of seamed or fractured rock. Upon checking with the drill, relatively sound cores were obtained in this zone. The comparatively low velocity of 5,000 feet per second for shallow and fractured rock is not uncommon in other formations but because of the unusually sound character of the rock previously encountered in these investigations, this condition was not anticipated. The low velocity is probably the result of open seams caused by frost action and the absence of a heavy overburden. Under a heavy overburden it is believed that this rock would have exhibited a much higher velocity.

43. To further investigate and study the condition found in the Rockway Canal, experimental seismic tests (S 388 to S 391 inclusive) were conducted in the vicinity of the Northern Quarries near Norfolk, New York. At the quarries, where the rock face was exposed it could be seen that a fractured and weathered zone existed to a depth of several feet. This rock was under a shallow overburden and of the same origin as that in the Point Rockway Canal. The seismic tests adjacent to the quarries produced graphs very similar to those shown on Plate X, verifying the results obtained in the canal.

44. Effect of Frozen Ground. - The velocity of wave propagation in frozen soil is much higher than that in normal or unfrozen topsoil and this condition leads to uncertainties in the interpretation of seismic data. Beginning about December 1, 1940, frozen ground began to affect the seismic data and introduced uncertainties into the interpretations. The effect of 6-inches of frozen ground is shown on Plate XI. Velocities of 5,000 to 7,000 feet per second, values abnormally high for topsoil, were obtained up to shooting distance of about 100 feet. For longer shooting distances the crust of frozen ground did not carry sufficient energy to register on the film. Probable solutions as indicated by the dotted lines on Plate XI were worked out for many of the lines affected by frost. These are believed to be reasonably accurate as regards total depth of overburden but the graphs are of little value for indicating the soil profile or character of the overburden. Unfortunately many of the lines affected by frost were in the Long Sault Canal area where it was desired to obtain overburden information.

45. Correlation with Drill Holes. - The correlation between seismic information and drilling data has been thoroughly investigated over the whole project. Table III compares data from seismic lines and drill holes less than 250 feet apart. In a few locations drill holes were spotted at or near the centers of seismic lines for the express purpose of checking the seismic predictions. This is true for lines 203 and 246 on Galop Island and line 318, 320, 323, and 325 in the Rockway Canal area.

On Galop Island the checks were remarkably close being 1 foot in a depth of 42.3 feet and 1.5 feet in a depth of 54.0 feet, respectively. Correlations in the Rockway Canal area were not entirely satisfactory, owing to the presence of shallow rock as previously described. At line 269, near the Massena Power Canal intake an error of 9.9 feet in a depth of 67.2 feet occurred. Failure at this location to determine the depth of rock more accurately is the result of an artificial condition created by the dumping of spoil from the excavation of the power canal. The fill in the area covered by line S 269 is very deep at places and quite shallow at others. As a result of this condition the time-distance graph for this line is very erratic and difficult of precise interpretation. With the exception of this line and few of those in the Rockway Canal area the correlations in Table III are quite satisfactory and indeed much better than ordinarily obtained in geophysical explorations. For the greater depths the differences are relatively small while for the shallower overburdens such as at lines S 89, S 164, S 175, S 318, and S 325, the actual differences, although only a few feet, may represent a large percentage of error. It should be noted, however, that in all cases the drill record gives the depth of the overburden at one precise location while the seismograph records an average depth over a considerable length of line.

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-1	Long Sault Dam	A-XI	1,819,246	364,231	79° 47'	174.5	140.2	Satisfactory
S-2	Long Sault Dam	A-XI	1,820,005	363,398	103° 52'	174.8	145.1	"
S-3	"	"	1,819,942	362,696	234° 49'	176.0	151.9	"
S-4	"	"	1,819,098	361,507	233° 18'	227.9	157.9	"
S-5	"	"	1,819,290	361,992	237° 42'	238.1	148.7	"
S-6	"	*	1,819,145	360,623	210° 03'	179.2		No data
S-7	"	A-XI	1,820,725	361,207	192° 04'	202.8	163.1	Fair
S-8	"	"	1,821,226	361,279	82° 39'	173.5	158.1	Satisfactory
S-9	"	"	1,820,350	361,030	263° 02'	177.3	154.1	"
S-10	"	"	1,820,638	361,371	187° 17'	214.9	152.4	"
S-11	"	"	1,820,626	361,597	177° 03'	212.7	156.1	"
S-12	"	"	1,820,614	361,786	174° 54'	212.5	160.0	"
S-13	"	"	1,820,738	362,018	175° 42'	212.2	157.3	"
S-14	"	"	1,820,391	362,262	25° 17'	172.2	163.3	"
S-15	"	"	1,820,352	362,241	70° 26'	172.9	165.0	"
S-16	Long Sault Island	"	1,820,595	355,272	224° 04'	227.6	178.6	"
S-17	"	"	1,821,192	355,885	37° 17'	233.3	189.1	"
S-18	"	"	1,821,193	356,424	218° 02'	271.4	184.2	"
S-19	"	"	1,819,929	355,493	223° 00'	249.4	167.6	"
S-20	"	*	1,819,085	355,311	207° 25'	262.0		No Data
S-21	"	A-XI	1,818,545	355,882	206° 11'	222.7	168.9	Fair
S-22	"	"	1,819,392	356,318	213° 33'	225.7	163.0	Satisfactory
S-23	"	*	1,820,210	356,914	225° 24'	228.0		No data
S-24	Long Sault Canal	A-XI	1,817,621	352,786	229° 52'	224.7	167.2	Satisfactory
S-25	"	"	1,815,838	355,047	48° 12'	202.4	156.1	Fair
S-26	Powerhouse	A-XVII	1,824,492	378,604	173° 27'	215.4	149.9	Fair
S-27	"	"	1,824,521	378,839	174° 10'	202.5	138.8	Satisfactory
S-28	Massena Canal Int. Wks.	*	1,806,753	346,617	168° 32'	242.0		Unsatisfactory
S-29	"	A-X	1,807,358	345,461	94° 17'	231.9	162.5	Satisfactory
S-30	"	*	1,808,064	345,848	335° 23'	220.8		No data
S-31	"	*	1,808,213	345,321	40° 58'	227.5		Unsatisfactory
S-32	"	*	1,808,777	347,139	49° 15'	225.9		Unsatisfactory
S-33	Power House	A-XVII	1,827,101	379,658	313° 45'	185.9	151.0	Fair
S-34	"	"	1,827,165	379,950	323° 00'	185.6	142.0	Satisfactory
S-35	New Cornwall Canal	A-XVIII	1,826,849	382,474	308° 01'	191.9	133.2	"
S-36	"	"	1,827,981	381,553	297° 30'	204.5	155.7	"
S-37	"	A-XVIII	1,828,477	380,904	95° 38'	214.3	145.3	"
S-38	"	A-XVIII	1,828,843	379,923	138° 02'	211.8	164.4	Fair
S-39	"	"	1,829,973	379,157	329° 56'	210.6	158.9	Fair
S-40	"	"	1,830,576	381,150	258° 42	209.8	162.0	Satisfactory
S-41	"	"	1,831,082	378,088	303° 28'	231.8	161.4	"
S-42	Long Sault Dam	A-XI	1,819,757	363,152	115° 50' 249° 53'	245.2	148.2	"
S-43	"	*	1,815,516	356,947	127° 21'	229.2		No data
S-44	Iroquois Dam	A-V	1,763,327	246,564	331° 20'	229.2	212.0	Fair
S-45	"	"	1,762,913	246,800	336° 11'	229.0	200.8	Fair
S-46	"	"	1,761,007	247,315	25° 31'	230.2	171.0	Fair
S-47	"	"	1,761,938	247,082	325° 55'	229.9	170.0	Satisfactory
S-48	"	"	1,761,387	247,097	152° 23'	245.7	175.0	"
S-49	"	"	1,762,077	246,691	149° 11'	268.7	192.7	"
S-50	Point Rockway Canal	A-VI	1,760,508	249,891	306° 08'	231.5	206.5	"
S-51	Iroquois Dam	A-V	1,761,050	249,398	152° 44'	241.1	185.6	"
S-52	"	"	1,761,442	249,761	155° 00'	257.4	167.3	"
S-53	Point Rockway Canal	A-VI	1,760,762	250,196	327° 28'	241.6	215.0	"
S-54	"	"	1,760,526	250,553	43° 47'	232.4	207.0	"
S-55	Iroquois Dam	A-V	1,762,337	249,072	324° 22'	266.3	203.7	"
S-56	Long Sault Island	A-XI	1,819,247	354,312	36° 33'	221.5	170.3	"
S-57	"	A-XI	1,819,739	353,992	269° 14'	217.7	170.0	"
S-58	"	"	1,819,556	353,287	137° 13'	224.0	176.7	"
S-59	"	"	1,819,128	353,676	222° 47'	217.7	162.8	"
S-60	Long Sault Canal	A-XIII	1,817,568	369,660	72° 08'	254.3	159.2	"
S-61	"	"	1,816,985	367,944	240° 39'	238.9	149.9	"
S-62	"	"	1,814,212	366,044	245° 38'	245.0	158.1	"
S-63	"	"	1,815,534	366,006	27° 30'	250.2	152.2	"
S-64	"	A-XVI	1,816,241	382,147	175° 28'	245.0	<155.0	Fair
S-65	"	"	1,817,874	382,193	280° 47'	181.5	127.0	Fair
S-66	"	"	1,817,697	383,853	277° 52'	184.0	109.7	Satisfactory
S-67	"	A-XII	1,813,997	363,473	193° 19'	221.4	139.0	"
S-68	"	A-XIII	1,814,084	367,700	235° 06'	199.7	134.5	Fair
S-69	"	A-XIV	1,817,607	376,865	267° 37'	188.9	127.5	Satisfactory
S-70	Ogden Island	A-VII	1,778,479	271,158	84° 23'	245.7	194.2	"

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-71	Ogden Island	A-VII	1,777,918	270,281	280° 15' 28° 54'	247.3	221.7	Satisfactory
S-72	"	"	1,778,039	271,359	85° 09'	262.5	202.2	Fair
S-73	"	"	1,778,157	272,292	128° 34'	242.7	197.3	Satisfactory
S-74	"	"	1,774,750	265,427	249° 49'	232.1	179.1	Satisfactory
S-75	"	"	1,774,379	264,500	236° 45'	229.0	182.4	"
S-76	"	"	1,773,815	263,978	193° 15'	236.7	198.9	"
S-77	Leishmans Point	A-VII	1,771,244	264,590	106° 07'	234.4	212.0	"
S-78	"	"	1,771,234	263,415	59° 25'	237.2	193.4	"
S-79	"	"	1,770,699	262,453	196° 58'	243.7	205.6	Fair
S-80	Ogden Island	A-VIII	1,779,923	276,408	53° 28'	228.9	168.9	Satisfactory
S-81	"	"	1,779,331	276,301	41° 51' 219° 48'	239.1	169.8	"
S-82	"	"	1,778,799	275,664	64° 05' 241° 41'	245.6	184.8	"
S-83	"	A-VII	1,774,928	272,060	81° 44'	232.6	191.6	"
S-84	"	"	1,775,208	271,897	75° 32'	230.1	193.7	"
S-85	"	"	1,775,007	270,960	78° 28'	230.5	175.2	"
S-86	"	"	1,774,984	269,987	287° 13'	232.2	209.5	"
S-87	"	"	1,774,575	270,251	239° 59'	231.6	178.9	"
S-88	Point Rockway Canal	A-VI	1,768,168	258,368	214° 00'	228.5	201.7	"
S-89	"	"	1,767,416	257,823	38° 13'	229.5	199.5	"
S-90	"	"	1,766,548	257,326	208°12'	230.3	195.5	"
S-91	Iroquois Dam	A-V	1,760,752	249,463	332° 54'	233.5	195.2	"
S-92	Point Three Points	A-VI	1,769,342	256,682	228° 43'	236.5	179.8	"
S-93	"	A-VII	1,769,978	257,556	67° 52'	235.7	190.6	"
S-94	"	"	1,769,579	257,399	63° 01'	247.7	191.5	"
S-95	"	A-VI	1,768,826	255,863	243° 25'	235.6	173.8	Fair
S-96	"	"	1,768,295	255,228	212° 44'	246.1	174.6	Satisfactory
S-97	Point Rockway Canal	"	1,765,104	256,218	32° 05'	233.2	199.6	"
S-98	Long Sault Canal	A-XIII	1,813,742	364,557	208° 10'	233.7	145.1	"
S-99	"	"	1,814,035	365,209	204° 12'	237.9	151.5	"
S-100	"	*	1,816,917	375,612	84° 01'	202.7		Unsatisfactory
S-101	"	A-XIV	1,815,564	375,224	195° 02'	231.7	<131.7	Satisfactory
S-102	"	"	1,815,631	376,207	148° 18'	230.8	<120.8	"
S-103	"	XII	1,814,805	359,334	291° 23'	226.3	175.5	"
S-104	"	"	1,813,793	362,289	248° 26'	216.0	151.0	"
S-105	"	*	1,817,584	379,978	257° 58'	184.1		No data
S-106	"	*	1,816,871	380,089	27° 19'	205.3		Unsatisfactory
S-107	"	A-XV	1,815,665	379,685	186° 48'	235.7	<134.0	Fair
S-108	"	*	1,814,776	365,567	6° 46' 217° 08'	254.3		Unsatisfactory
S-109	"	*	1,814,954	366,502	223° 11'	247.6		No data
S-110	"	*	1,814,763	366,997	227° 00'	208.0		"
S-111	"	A-XIII	1,814,823	367,507	258° 21'	200.7	154.7	Fair
S-112	Long Sault Dam	A-XI	1,818,917	362,484	67° 43'	271.3	<152.0	Satisfactory
S-113	"	"	1,819,567	363,271	139° 37'	252.5	147.5	"
S-114	Point Rockway Canal	A-VI	1,763,511	255,138	60° 18'	240.1	201.1	Satisfactory
S-115	"	"	1,762,976	253,813	68° 23'	241.5	226.0	"
S-116	"	"	1,762,331	252,494	47° 15'	235.8	179.1	Fair
S-117	Ogden Island	A-VII	1,774,645	269,627	17°09'	234.9	212.7	Satisfactory
S-118	"	"	1,775,275	269,243	295° 32'	235.5	207.0	Fair
S-119	"	"	1,775,179	268,678	261° 30'	235.1	207.0	Fair
S-120	Long Sault Canal	*	1,815,007	368,376	77° 47'	198.8		Unsatisfactory
S-121	Massena Canal Int. Wks.	*	1,808,461	347,025	164° 20'	242.9		"
S-122	Ogden Island	A-VII	1,775,077	269,390	295° 44'	235.5	217.5	Satisfactory
S-123	"	"	1,775,839	273,273	232° 29'	238.4	192.9	Fair
S-124	Leishmans Point	"	1,772,371	263,454	170° 01'	238.8	203.1	Fair
S-125	"	"	1,772,592	263,079	64° 33'	234.5	203.9	Fair
S-126	"	"	1,772,182	263,053	216° 22'	244.7	201.1	Satisfactory
S-127	"	"	1,771,956	262,570	38° 49'	244.7	200.2	Fair
S-128	Long Sault Canal	*	1,818,049	384,682	158°13'	184.0		Unsatisfactory
S-129	"	*	1,818,775	384,390	158° 05'	187.8		"
S-130	"	*	1,819,498	384,097	337° 36'	188.8		No data
S-131	"	*	1,820,241	383,796	338° 39'	193.6		Unsatisfactory
S-132	"	*	1,818,034	383,622	157° 19'	185.9		No data
S-133	"	*	1,818,754	383,316	158° 01'	189.5		No data
S-134	"	*	1,819,478	383,021	157° 20'	195.6		Unsatisfactory
S-135	"	*	1,820,182	383,023	24° 47'	196.4		"

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-136	Long Sault Canal	*	1,817,476	384,588	245° 04'	176.0		Unsatisfactory
S-137	"	*	1,817,151	383,865	245° 22'	180.0		"
S-138	"	*	1,816,825	383,133	246° 04'	196.7		"
S-139	"	*	1,818,889	381,029	180° 47'	196.8		No data
S-140	"	*	1,819,689	380,988	254° 58'	203.3		No data
S-141	"	A-XV	1,817,345	380,736	74° 25'	188.7	105.3	Fair
S-142	"	*	1,818,568	379,916	172° 29'	197.4		No data
S-143	"	*	1,816,644	371,520	132° 23'	204.1		Unsatisfactory
S-144	"	*	1,815,989	372,756	261° 38'	200.7		"
S-145	"	*	1,816,661	373,262	222° 17'	201.6		"
S-146	"	*	1,818,551	377,239	176° 53'	220.8		"
S-147	"	*	1,817,589	377,416	165° 47'	186.4		"
S-148	"	A-XIV	1,816,396	377,660	173° 26'	202.9	97.7	Fair
S-149	Ogden Island Cut	A-VII	1,772,289	269,398	242° 16'	234.0	225.7	Fair
S-150	"	"	1,771,794	268,768	54° 54'	255.4	214.2	Fair
S-151	Long Sault Canal	A-XIII	1,816,205	368,792	55° 13'	226.9	153.5	Fair
S-152	"	*	1,816,287	369,184	51° 18'	205.5		No data
S-153	"	*	1,815,654	369,519	241° 30'	198.7		No data
S-154	Ogden Island	*	Experimental Line-Not plotted					No data
S-155	Massena Ca[illegible]	*	1,808,055	345,890	152° 48'	222.0		Unsatisfactory
S-156	"	*	1,808,176	345,638	180° 13'	234.0		"
S-157	"	*	1,808,199	345,522	194° 31'	234.7		"
S-158	"	A-X	1,808,362	345,280	224° 15'	218.4	176.8	Fair
S-159	"	*	1,807,837	345,444	281° 05'	228.4		Unsatisfactory
S-160	"	A-X	1,808,210	345,332	198° 11'	227.8	171.9	Satisfactory
S-161	Sparrowhawk [illegible]	A-IV	1,752,890	238,056	148° 23'	250.1	176.4	Fair
S-162	"	"	1,752,824	237,661	49° 29'	238.4	178.2	Satisfactory
S-163	"	"	1,752,252	236,944	20° 27'	253.4	177.9	Fair
S-164	Point Rockway Canal	A-VI	1,769,065	258,995	19° 21'	228.0	206.9	Satisfactory
S-165	"	"	1,767,861	259,062	176° 09'	246.7	207.0	"
S-166	"	"	1,768,595	258,008	22° 54'	234.7	211.2	"
S-167	"	"	1,767,568	257,089	204° 05'	244.5	207.8	"
S-168	"	"	1,765,185	255,445	220° 37'	268.3	192.3	"
S-169	"	"	1,766,083	256,601	207° 20'	233.4	195.5	"
S-170	"	"	1,765,389	257,018	189° 34'	233.1	200.6	"
S-171	"	"	1,765,641	257,772	52° 33'	241.7	220.3	"
S-172	"	"	1,763,146	255,952	236° 02'	237.1	211.8	"
S-173	"	"	1,763,998	256,721	45° 19'	236.0	222.7	"
S-174	"	"	1,762,614	254,807	80° 38'	243.8	206.9	"
S-175	"	"	1,762,305	253,898	65° 21'	241.1	232.1	"
S-176	"	"	1,761,814	253,036	50° 34'	239.8	219.5(234.5)**	"
S-177	"	"	1,760,188	250,652	251° 34'	231.5	212.9	"
S-178	"	"	1,760,570	251,563	234° 47'	234.4	204.1	"
S-179	"	"	1,761,263	252,369	233° 25'	234.8	222.4	"
S-180	Cornwall Island	A-XX				Depth	40.6	"
S-181	"	"				Depth	46.0	"
S-182	Lotus Island	*	1,745,330	231,350	160° 28'	245.6		No data
S-183	"	A-IV	1,745,891	231,381	351° 28'	244.1	180.2	Satisfactory
S-184	N. Y. Mainland Opp. Massena Pt.		Quarry Survey--Not plotted			Depth	94.8	"
S-185	Lotus Island	A-IV	1,746,144	232,149	105° 39'	246.6	190.9	"
S-186	"	"	1,745,588	232,036	72° 23'	246.7	187.0	"
S-187	Lalone Island	A-III	1,743,115	231,156	231° 30'	253.0	219.6	"
S-188	"	A-III	1,742,620	230,392	245° 47'	256.4	223.7	"
S-189	"	"	1,743,198	229,502	160° 44'	260.8	201.7	"
S-190	"	"	1,743,965	229,407	45° 43'	237.3	202.7	"
S-191	"	"	1,743,506	229,819	189° 14'	254.5	215.0	"
S-192	"	"	1,743,248	229,859	69° 27'	256.3	213.1	"
S-193	"	"	1,743,701	230,155	206° 05'	260.2	216.1	"
S-194	Toussaints Island Channel	A-IV	1,753,906	240,272	45° 51'	240.1	<168.0	"
S-195	"	"	1,754,207	240,708	207° 06'	235.7	<157.0	"
S-196	"	"	1,754,279	239,982	50° 41'	249.4	<174.0	"
S-197	"	"	1,754,630	240,110	57° 47'	250.3	<183.0	"
S-198	"	"	1,754,973	240,734	61° 02'	244.4	<159.0	"
S-199	"	"	1,755,133	241,250	57° 41'	239.0	<155.0	"
S-200	Galop Island Channel	A-II	1,737,602	220,361	133° 52'	245.7	218.4	"
S-201	"	"	1,737,842	220,910	330° 18'	257.2	214.0	"
S-202	"	"	1,738,070	219,845	334° 35'	244.7	202.7	"
S-203	"	"	1,738,299	220,172	358° 06'	247.7	206.4	"
S-204	"	"	1,738,746	220,178	358° 46'	246.5	213.1	"
S-205	"	"	1,738,178	220,761	80° 24'	257.4	210.1	"

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-206	Galop Island Channel	A-II	1,738,669	219,579	296° 27'	255.0	218.9	Satisfactory
S-207	Lalone Island	A-III	1,742,448	231,190	40° 25'	236.5	221.5	"
S-208	"	"	1,742,203	231,314	234° 35'	257.2	223.6	"
S-209	Point Rockway Canal	A-VI	1,759,918	250,122	181° 56'	231.9	204.6	"
S-210	"	"	1,760,526	250,350	180° 58'	232.6	204.4	"
S-211	"	"	1,759,877	250,498	27° 20'	247.0	213.0	"
S-212	"	"	1,760,360	251,180		233.0	210.2	"
S-213	"	"	1,760,322	251,802	254° 13'	238.0	203.8	"
S-214	"	"	1,760,020	252,090		245.0	226.2	"
S-215	Galop Island Channel	A-II	1,738,578	221,028	216° 34'	258.5	202.6	"
S-216	"	"	1,739,124	221,300	165° 28'	265.4	182.3	"
S-217	"	"	1,739,112	219,448	209° 27'	265.5	223.3	"
S-218	"	"	1,739,482	219,406	212° 33'	279.0	227.8	"
S-219	"	"	1,738,905	219,128	326° 39'	243.9	229.0	"
S-220	"	"	1,739,767	219,957	155° 03'	282.4	231.6	"
S-221	"	"	1,739,246	220,053	345° 38'	246.0	214.0	"
S-222	"	"	1,739,184	220,400	143° 28'	255.4	<184.4	"
S-223	"	"	1,740,224	220,293	218° 48'	241.0	226.9	"
S-224	"	"	1,739,781	220,610	71° 58'	259.3	<202.4	"
S-225	"	"	1,739,703	221,160	285° 50'	272.5	197.5	"
S-226	"	"	1,740,452	221,097	90° 02'	268.8	222.1	"
S-227	"	"	1,740,720	220,667	42° 06'	240.5	228.7	"
S-228	"	"	1,740,174	221,163	276° 53'	274.2	217.3	"
S-229	"	"	1,739,922	221,641	329° 05'	254.4	179.9	"
S-230	"	"	1,739,409	221,320	267° 39'	266.7	188.0	"
S-231	"	"	1,738,855	222,146	181° 58'	252.3	240.6	"
S-232	"	"	1,739,088	222,314	170° 29'	257.4	245.4	"
S-233	"	"	1,739,279	222,055	261° 46'	251.8	203.8	"
S-234	"	"	1,739,634	222,331	334° 01'	239.2	230.4	"
S-235	"	"	1,739,655	222,678	8° 06'	240.1	232.1	"
S-236	"	"	1,739,689	222,923	171° 54'	280.5	234.5	"
S-237	"	"	1,740,205	222,708	357° 51'	239.3	223.2	"
S-238	"	"	1,740,530	223,019	357° 51'	239.2	219.7	"
S-239	"	"	1,740,151	223,651	237° 54'	239.4	234.2	"
S-240	"	"	1,740,707	223,985	181° 27'	239.1	232.7	"
S-241	"	"	1,741,200	224,040	22° 10'	239.9	210.5	"
S-242	"	"	1,741,130	224,369	161° 35'	239.4	231.1	"
S-243	"	"	1,741,230	224,987	180° 27'	239.6	233.6	"
S-244	"	"	1,741,972	225,120	184° 26'	239.2	201.9	"
S-245	"	"	1,742,342	225,545	148° 39'	238.5	215.8	"
S-246	"	"	1,742,130	225,440	354° 47'	250.2	197.7	"
S-247	"	"	1,741,771	225,709	163° 31'	238.3	226.8	"
S-248	"	"	1,740,856	225,133	181° 53'	272.4	231.7	"
S-249	"	A-III	1,742,902	226,216	357° 34'	236.9	199.4	"
S-250	"	"	1,742,865	226,443	147° 19'	236.6	202.2	"
S-251	"	"	1,742,315	226,283	349° 34'	237.3	203.1	"
S-252	"	A-II	1,737,825	220,036	115° 02'	245.6	208.7	"
S-253	"	"	1,738,436	219,549	302° 02'	244.4	222.4	"
S-254	"	"	1,738,531	219,876	312° 22'	257.3	218.8	"
S-255	Power House	A-XVII	1,823,564	379,147	206° 51'	160.0	100.5	"
S-256	"	"	1,824,056	379,275	214° 33'	190.6	112.0	Satisfactory
S-257	"	"	1,824,345	379,791	42° 43'	159.5	110.3	"
S-258	"	"	1,824,973	379,916	358° 43'	159.1	110.8	"
S-259	"	"	1,825,573	381,023	281° 26'	160.5	100.9	"
S-260	"	"	1,825,515	381,409	88° 19'	159.8	107.6	"
S-261	"	"	1,825,662	382,124	74° 19'	160.0	109.0	"
S-262	Galop Island Channel	*	1,736,306	218,236	154° 52'	243.6		Unsatisfactory
S-263	"	A-III	1,735,846	218,420	349° 26'	242.9	202.9	Satisfactory
S-264	"	"	1,735,312	218,331	275° 31'	248.9	204.1	"
S-265	"	"	1,734,378	218,001	167° 49'	246.9	191.2	"
S-266	Massena Canal Int. Wks.	A-X	1,807,814	345,393	100° 48'	225.9	170.8	"
S-267	"	"	1,808,039	345,484	106° 09'	227.4	170.1	"
S-268	"	"	1,808,082	345,758	179° 13'	222.4	169.4	"
S-269	"	*	1,808,192	345,529	216° 02'	234.1		Unsatisfactory
S-270	Galop Island Channel	A-II	1,737,186	220,291	123° 50'	237.7	209.7	Satisfactory

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-271	Galop Island Channel	A-III	1,735,838	219,387	123° 50'	236.8	221.8	Satisfactory
S-272	"	A-II	1,737,199	219,783	124° 14'	236.4	199.4	"
S-273	"	A-III	1,736,498	219,386	124° 14'	238.9	211.4	"
S-274	"	"	1,735,917	218,914	124° 14'	240.4	211.4	"
S-275	"	A-II	1,738,033	219,537	126° 46'	237.4	201.0	"
S-276	"	A-III	1,737,415	219,060	126° 46'	238.4	206.4	"
S-277	"	"	1,736,851	218,646	126° 46'	239.4	211.7	"
S-278	"	A-II	1,740,389	222,174	358° 54'	232.3	212.2	Fair
S-279	"	"	1,739,919	222,401	346° 43'	233.3	221.4	Fair
S-280	"	"	1,740,262	222,481	344° 21'	230.3	212.7	Satisfactory
S-281	"	"	1,739,979	222,463	22° 57'	233.3	218.8	"
S-282	"	"	1,740,169	221,783	83° 09'	231.9	195.3	"
S-283	"	"	1,740,826	223,204	61° 40'	226.7	211.3	"
S-284	"	"	1,740,971	223,675	63° 51'	230.7	217.5	"
S-285	"	"	1,740,459	223,260	328° 48'	230.0	219.3	"
S-286	"	"	1,740,577	223,501	329° 54'	229.8	221.5	"
S-287	"	"	1,740,746	223,692	358° 30'	230.0	227.0	"
S-288	"	"	1,741,450	224,402	331° 46'	230.5	214.5	"
S-289	"	"	1,741,780	224,498	46° 39'	230.5	203.5	"
S-290	"	"	1,741,140	224,698	86° 40'	233.5	228.2	"
S-291	"	"	1,741,279	224,643	85° 49'	229.6	227.0	"
S-292	"	"	1,741,536	224,960	3° 58'	234.7	223.5	"
S-293	Racquette Point Cut	A-XX	1,820,969	399,587	239° 31'	153.8	101.2	"
S-294	"	"	1,820,158	399,668	185° 08'	154.7	96.9	"
S-295	"	"	1,821,270	400,246	68° 06'	152.9	110.9	"
S-296	"	"	1,820,486	400,214	5° 17'	192.3	101.3	"
S-297	Iroquois Dam	A-V	1,761,216	249,237	161° 20'	232.6	168.1	"
S-298	"	"	1,761,731	249,205	172° 52'	230.5	194.3	"
S-299	"	"	1,760,667	249,515	152° 28'	233.5	201.9	"
S-300	"	"	1,760,929	249,598	105° 59'	239.1	189.1	"
S-301	"	"	1,760,792	249,771	108° 01'	238.6	203.3	"
S-302	"	"	1,761,538	249,296	359° 42'	259.0	170.6	"
S-303	"	"	1,762,216	249,151	330° 53'	266.0	199.5	"
S-304	R.R. Bridge, Power Canal	A-XIX	1,802,255	356,316	130° 47'	212.3	146.0	"
S-305	"	"	1,802,480	356,035	127° 02'	211.3	139.8	"
S-306	"	"	1,802,250	355,863	311° 43'	199.9	145.2	"
S-307	"	"	1,802,033	356,094	116° 55'	200.2	147.5	"
S-308	Racquette Point Channel	A-XX	1,820,188	402,043	354° 14'	183.8	89.3	"
S-309	Leishmans Point	A-VII	1,771,138	265,013	112° 22'	225.6	218.0	"
S-310	"	"	1,770,444	261,601	12° 25'	226.1	206.9	"
S-311	"	"	1,770,463	263,035	255° 39'	232.2	192.2	"
S-312	"	"	1,772,728	263,155	68° 20'	225.8	199.3	"
S-313	"	"	1,772,254	262,524	43° 13'	225.6	193.0	"
S-314	"	"	1,771,600	262,124	13° 44'	225.9	197.3	"
S-315	Point Rockway Canal	A-VI	1,763,207	255,439		237.0	208.2	"
S-316	"	"	1,763,229	255,073		239.9	210.5	"
S-317	"	"	1,762,915	254,562		239.4	218.4	"
S-318	"	"	1,762,726	254,678		240.1	209.7	Fair
S-319	"	"	1,762,945	254,191		237.9	224.3(230.9)**	Satis.
S-320	"	"	1,762,631	253,680		237.1	222.5(232.6)**	Fair
S-321	"	"	1,762,316	253,169		235.3	198.5	Satisfactory
S-322	"	"	1,762,128	253,285		238.2	232.4	"
S-323	"	"	1,761,782	253,146		244.6	223.9(240.3)**	"
S-324	"	"	1,762,001	252,658		234.3	218.0	"
S-325	"	"	1,761,656	252,519		233.2	226.5(229.5)**	"
S-326	"	"	1,764,481	256,280		230.1	224.1	"
S-327	"	"	1,764,058	255,800		238.8	230.2	"
S-328	"	"	1,763,953	255,995		233.6	223.1	"
S-329	"	"	1,763,848	256,190		233.3	217.0	"
S-330	"	"	1,764,586	256,085		238.2	215.0	"
S-331	"	"	1,764,376	256,474		236.7	213.9	"
S-332	"	"	1,764,904	256,759		235.1	212.9	Fair
S-333	"	"	1,765,014	256,355		231.8	208.6	Fair
S-334	Iroquois Dam	A-V	1,761,080	249,266		229.8	169.0	Satisfactory
S-335	Chimney Island Channel	A-I	1,730,378	212,065		235.0	183.7	"

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-336	Chimney Island Channel	A-I	1,730,391	211,798		239.0	182.0	Satisfactory
S-337	"	"	1,730,197	211,151		238.1	176.1	"
S-338	"	"	1,731,032	213,309		200.1	182.6	Fair
S-339	"	"	1,730,634	201,448		234.0	175.0	Satisfactory
S-340	"	"	1,731,012	212,561		222.0	185.8	"
S-341	"	"	1,731,218	214,145		236.9	178.2	"
S-342	"	"	1,732,032	214,225		203.9	<200.0	Fair
S-343	"	"	1,730,047	211,367		239.0	185.0	Satisfactory
S-344	"	"	1,730,389	210,735	18° 22'	219.0	<200.0	Fair
S-345	"	"	1,729,711	210,458	20° 01'	212.0	181.2	Satisfactory
S-346	"	"	1,729,855	209,715	54° 02'	227.0	163.0	"
S-347	"	"	1,729,333	209,558	241° 43'	224.0	184.5	"
S-348	"	"	1,729,664	211,706		244.1	200.0	"
S-349	Galop Island Channel	A-II	1,738,043	220,181	22° 37'	245.5	203.9	"
S-350	"	"	1,738,191	220,433	59° 53'	248.7	210.5	"
S-351	"	"	1,738,395	220,803	64° 26'	256.7	201.0	"
S-352	"	"	1,740,038	221,511	58° 54'	258.3	190.3	"
S-353	"	"	1,739,832	221,171	238° 38'	274.3	199.6	"
S-354	"	"	1,739,515	220,657	58° 43'	259.1	205.9	"
S-355	"	"	1,739,360	220,402	238° 16'	256.8	186.5	"
S-356	"	"	1,739,057	219,848	198° 31'	255.1	217.3	"
S-357	"	"	1,738,920	219,581	182° 59'	260.3	227.3	"
S-358	"	"	1,739,256	221,860	234° 41'	254.5	202.0	"
S-359	"	"	1,739,074	221,618	344° 55'	265.9	191.9	"
S-360	"	"	1,739,406	221,429	238° 28'	266.6	195.9	"
S-361	"	"	1,739,206	220,970	58° 31'	261.6	188.2	"
S-362	"	"	1,738,935	220,663	162° 58'	261.0	190.7	"
S-363	"	"	1,738,535	220,178	45'	246.7	215.2	"
S-364	"	"	1,738,927	220,178	1° 51'	247.1	219.3	"
S-365	"	"	1,738,771	219,922	8° 25'	258.7	222.4	"
S-366	"	"	1,739,088	220,437	153° 33'	256.7	189.7	"
S-367	"	"	1,739,247	220,595	58° 48'	258.7	179.8	"
S-368	"	"	1,739,408	220,957	57° 23'	265.3	186.1	"
S-369	"	"	1,739,886	222,853	7° 31'	269.3	233.3	"
S-370	"	"	1,741,414	225,331	40° 05'	260.7	222.7	"
S-371	"	"	1,737,626	220,650	58° 58'	250.3	216.5	"
S-372	"	"	1,738,181	221,373	49° 22'	257.3	217.2	"
S-373	"	"	1,738,506	221,840	54° 51'	253.7	215.4	"
S-374	"	"	1,739,215	222,839	8° 57'	272.5	242.1	"
S-375	"	"	1,739,563	223,328	235° 11'	280.1	243.0	"
S-376	"	"	1,738,734	219,228	327° 37'	244.0	233.8	"
S-377	"	"	1,739,551	221,609	340° 11'	257.8	204.2	"
S-378	"	"	1,740,244	224,288	51° 34'	277.6	244.0	"
S-379	"	"	1,740,564	224,740	54° 58'	269.9	243.7	Fair
S-380	"	"	1,740,912	225,229	51° 58'	271.0	230.6	Satisfactory
S-381	Point Rockway Canal	A-VI				237.6	191.2	"
S-382	Louisville Dike	*	Not on site			Depth	>102'	"
S-383	"	*	" " "			Depth	> 106'	"
S-384	"	*	" " "			Depth	> 106'	"
S-385	Bradford Pt. Dike	A-IX	1,794,677	314,628	338° 02'	241.6	171.2	"
S-386	"	"	1,793,406	215,444	345° 07'	243.4	150.5	"
S-387	"	"	1,792,650	316,190	312° 33'	267.6	161.3	"
S-388	Borman Quarry	*	Experimental line--not plotted					
S-389	"	*	"	"	" "			
S-390	"	*	"	"	" "			
S-391	"	*	"	"	" "			
S-392	Point Rockway Canal	A-VI				225.1	180.0	Satisfactory
S-393	Long Sault Dam	A-XI	1,819,432	357,471	154° 03'	183.4	159.8	"
S-394	"	"	1,819,324	356,878	26° 40'	182.0	159.3	"
S-395	Long Sault Island	*	Not on site--not plotted			Depth	57.7'	"
S-396	"	*	" " "	"	"	Depth	41.6	"
S-397	"	*	" " "	"	"	Depth	53.1	"
S-398	"	*	" " "	"	"	Depth	55.2	"
S-399	"	*	" " "	"	"	Depth	57.1	"
S-400	"	*	" " "	"	"	Depth	62.2	"

TABLE I

LOCATION OF SEISMIC LINES

ST. LAWRENCE RIVER PROJECT

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
S-401	Long Sault Island	A-XI	1,820,235	354,934	183° 44'	221.1	171.5	Satisfactory
S-402	"	"	1,819,710	354,794	15° 36'	219.4	165.9	"
S-403	"	"	1,819,903	354,471	79° 36'	197.1	169.1	"
S-404	"	"	1,820,111	355,107	200° 39'	245.8	168.9	"
S-405	"	"	1,819,990	355,522	32° 00'	249.4	160.1	"
S-406	"	"	1,819,672	355,218	177° 36'	257.9	166.2	"
S-407	"	"	1,819,923	355,961	182° 19'	260.8	175.1	"
S-408	"	"	1,819,873	356,344	205° 06'	249.0	176.6	"
S-409	"	"	1,819,587	355,613	231° 52'	260.1	168.0	"
S-410	"	"	1,819,924	356,777	47° 04'	182.7	171.0	"
S-411	"	"	1,819,585	356,558	205° 15'	180.9	169.3	"
S-412	"	"	1,819,573	356,040	270° 21'	275.5	180.0	Fair
S-413	Long Sault Dam	"	1,820,772	361,276	7° 08'	204.5	161.2	Fair
S-414	"	"	1,821,452	362,675		170.1	154.9	Satisfactory
S-415	Single Shot determination—see end of table							
S-416	" " " " " " "							
S-417	" " " " " " "							
S-418	" " " " " " "							
S-419	Massena Springs Quarry Site	A-XXI	Location approximate		—no survey	Depth	85.0	Satisfactory
S-420	Louisville Dike	A-IX	1,799,274	325,999	327° 10'	235.4	147.1	"
S-421	"	"	1,799,216	325,201	343° 08'	219.7	<149.9	"
S-422	"	"	1,799,643	324,138	237° 07'	238.4	143.5	"
S-423	Plum Brook Quarry Site	A-XXI	Location approx.—no survey			Depth	48.5'	"
S-424	Knapps Sta. Quarry Site	A-XXI	" "	" "	"	"	7.0'	"
S-425	"	"	" "	" "	"	"	33.4'	"
S-426	"	"	" "	" "	"	"	23.8'	"
S-427	"	"	" "	" "	"	"	25.8'	"
S-428	"	"	" "	" "	"	"	8.8'	"
S-429	"	"	" "	" "	"	"	15.5'	"
S-430	"	"	" "	" "	"	"	5.6'	"
S-431	"	"	" "	" "	"	"	14.4'	"
S-432	"	"	" "	" "	"	"	27.7	"
S-433	"	"	" "	" "	"	"	36.2'	"
S-434	"	"	" "	" "	"	"	23.7'	"
S-435	"	"	" "	" "	"	"	24.4'	"
S-436	"	"	" "	" "	"	"	16.9'	
S-437	"	"	" "	" "	"	"	7.7'	"
S-438	Hogansburg Quarry Site	"	" "	" "	"	"	>30.0'	Fair
S-439	"	*	" "	" "	"			No data
S-440	"	*	" "	" "	"			No data
S-441	"	*	" "	" "	"			No data
S-442	"	*	" "	" "	"			Unsatisfactory
S-443	"	*	" "	" "	"			"
S-444	"	A-XXI	" "	" "	"	Depth	7.0'	Fair
S-445	"	"	" "	" "	"	"	>35.0'	Satisfactory
S-446	"	"	" "	" "	"	"	>35.0'	"
S-447	"	"	" "	" "	"	"	>35.0'	Fair
S-448	"	"	" "	" "	"	"	26.0	Satisfactory
S-449	"	"	" "	" "	"	"	>26.0'	"
S-450	"	"	" "	" "	"	"	15.0'	"

SEISMIC LINE NO.	LOCATION	PLOTTED IN APPENDIX A PLATE NO.	COORDINATES NORTH	COORDINATES EAST	AZIMUTH	GROUND ELEV.	ROCK ELEV.	DATA
	Single Shot Determinations							
S-415	Long Sault Dam	A-XI	1,821,250	362,865		158.1	150.1	Satisfactory
S-416	"	"	1,821,134	362,921		157.1	154.0	"
S-417	"	"	1,821,060	362,990		157.1	138.1	"
S-418	"	"	1,821,006	363,069		156.1	138.1	"
SS-3,674	"	"	1,820,511	362,564		162.1	148.7	"
SS-3,675	"	"	1,820,708	362,860		155.1	149.2	"
SS-3,676	"	"	1,820,574	362,811		158.1	153.2	"
SS-3,677	"	*	1,820,496	362,889		160.1		No data
SS-3,678	"	A-XI	1,820,871	362,870		153.1	138.8	Satisfactory
SS-3,679	"	"	1,820,428	363,014		158.0	148.0	"
SS-3,680	"	"	1,820,983	362,546		169.0	144.0	"

* Not located by survey, not plotted because unsatisfactory data or line not laid out at correct location (Not on site)
** Due to the overburden and bedrock conditions in this area, the interpretation of the data is uncertain. Figures in parentheses are the probable surface elevation of slightly fractured and weathered bedrock. Figures not in parentheses are the probable elevation of sound bedrock.

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Chimney Island Channel				
S-335	9.0' of 0-4.6 4.6-51.3 Rock	Water 4,000 8,100 18,000	WS 244.0 G 235.0 R.183.7	Data for lines considered either satisfactory or fair. Shot distances were apparently inaccurate on some lines where water was deep. Overburden generally compact or dense (probably glacial till). Low velocities indicative of soft material were found on lines S338 and S341. Bedrock is well below grade.
S-336	5.0' of 0-57.0 Rock	Water 8,100 18,000	WS 244.0 G 239.0 R 182.0	
S-337	6.0' of 0-7.5 7.5-62.0 Rock	Water 5,500 8,100 17,500	WS 244.1 G 238.1 R 176.1	
S-338	44' of 0-17.5 Rock	Water 5,000 17,500	WS 244.1 G 200.1 R 182.6	
S-339	10.0' of 0-59.0 Rock	Water 8,330 17,500	WS 244.0 [illegible] R.175.0	
S-340	22.0' of 0-36.2 Rock	Water 8,500 18,000	WS 244.0 G 222.0 R 185.8	
S-341	7.0' of 0-58.7 Rock	Water 5,000 18,000	WS 243.9 G 236.9 R 178.2	
S-342	40.0' of 0-34.7 Rock below	Water 7,100	WS 243.9 G 203.9 200.0	
S-343	5.0' of 0-54.0 Rock	Water 8,200 18,000	WS 244.0 G 239.0 R 185.0	
S-344	25.0' of 0-50.8 Rock below	Water 8,000	WS 244.0 G 219.0 200.0	
S-345	32.0' of 0-30.8 Rock	Water 5,700 18,000	WS 244.0 G 212.0 R 181.2	
S-346	17.0' of 0-12.7 12.7-64.0 Rock	Water 5,700 7,700 16,250	WS 244.0 G 227.0 R 163.0	
S-347	20.0' of 0-39.5 Rock	Water 6,000 ?	WS 244.0 G 224.0 R 184.5	
S-348	0-13.0 13.0-44.0 Rock	4,700 8,000 16,000	G 244.0 R 200.0	
Galop Island Channel				
S-200	0-4.9 4.9-27.3 Rock	2,250 5,700 16,750	G 245.7 R 218.4	All data obtained throughout the Galop Island Channel area are satisfactory or fair except line S-262 on Tick Island for which the data were unsatisfactory. This area has been divided into 6 sections for discussion. 1. Galop Shoals upstream from Galop Island. The overburden consists of soft, or loose and compact material. Rock in the vicinity of the proposed channel is at or below grade. 2. Butternut Island. Rock below grade. Overburden consists of 20 feet of soft or loose material overlying compact dense material. 3. Tick Island--Overburden very compact and dense (apparently a glacial till). Rock is well below grade. 4. Galop Island--Overburden is variable but generally varies from fairly compact to compact dense material. Line S-375 indicated that soft or loose material extended to rock. The bedrock varied considerably from 30 feet above grade to 30 feet below grade. 5. Galop Island Bays--Bedrock is generally above grade in this area. The overburden (apparently is either soft or not very compact. 6. Dixon Island--Overburden is compact and dense (apparently glacial till). Bedrock appears to be slightly below grade in the area explored.
S-201	0-7.2 7.2-43.2 Rock	1,250 6,000 15,000	G 257.2 R 214.0	
S-202	0-4.6 4.6-42.0 Rock	2,000 7,150 15,650	G 244.7 R 202.7	
S-203	0-6.5 6.5-41.3 Rock	1,760 7,150 16,800	G 247.7 R 206.4	
S-204	0-5.8 5.8-33.4 Rock	1,670 6,460 16,000	G 246.5 R 213.1	
S-205	0-10.1 10.1-47.3 Rock	1,430 7,150 16,200	G 257.4 R 210.1	
S-206	0-7.8 7.8-36.1 Rock	1,250 5,560 17,200	G 255.0 R 218.9	
S-215	0-8.8 8.8-55.9 Rock	1,500 7,150 16,850	G 258.5 R 202.6	
S-216	0-7.2 7.2-24.0 24.0-83.1 Rock	1,870 5,000 9,400 16,400	G 265.4 R 182.3	
S-217	0-6.6 6.6-42.2 Rock	1,250 5,000 16,850	G 265.5 R 223.3	
S-218	0-7.9 7.9-51.2 Rock	1,500 6,300 15,250	G 279.0 R 227.8	
S-219	0-14.9 Rock	4,760 16,400	G 243.9 R 229.0	

WS-Water surface
G = Ground Surface
R = Rock Surface
FR = Fractured Rock

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Galop Island Channel (Con't.)				
S-220	0-8.1 8.1-50.8 Rock	1,430 5,650 17,000	G 282.4 R 231.6	
S-221	0-6.9 6.9-32.0 Rock	2,000 7,900 17,200	G 246.0 R 214.0	
S-222	0-7.0 7.0-71.0 Rock Below	1,250 8,150	G 255.4 184.4	
S-223	0-14.1 Rock	3,700 17,400	G 241.0 R 226.9	
S-224	0-8.1 8.1-57.0 Rock Below	1,430 6,800	G 259.3 202.3	
S-225 ahead	0-8.5 8.5-22.1 22.1-80.1	1,500 5,000 7,430	G 272.5	
back	0-8.5 8.5-69.8 Avg. Depth to Rock 75.0	1,500 5,000 17,500	 R 197.5	
S-226	0-7.3 7.3-46.7 Rock	1,250 5,000 18,000	G 268.8 R 222.1	
S-227	0-11.8 Rock	3,330 16,000	G 240.5 R 228.7	
S-228	0-8.1 8.1-56.9 Rock	1,430 5,700 16,000	G 274.2 R 217.3	
S-229	0-7.5 7.5-74.5 Rock	1,670 8,600 17,000	G 254.4 R 179.9	
S-230	0-11.0 11.0-78.7 Rock	1,670 7,800 17,500	G 266.7 R 188.0	
S-231	0-11.8 Rock	3,300 17,300	G 252.3 R 240.5	
S-232	0-12.0 Rock	1,670 18,000	G 257.4 R 245.4	
S-233	0-5.9 5.9-14.5 14.5-48.0 Rock	1,670 5,000 10,000 17,000	G 251.8 R 203.8	
S-234	0-8.8 Rock	3,000 16,000	G 239.2 R 230.4	
S-235	0-8.0 Rock	3,000 16,600	G 240.1 R 232.1	
S-236	0-6.8 6.8-46.0 Rock	1,670 5,000 17,000	G 280.5 R 234.5	
S-237	0-4.3 4.3-161 Rock	2,000 5,000 17,300	G 239.3 R 223.2	
S-238	0-5.0 5.0-19.5 Rock	2,500 7,000 16,600	G 239.2 R 219.7	
S-239	0-5.2 Rock	4,000 17,500	G 239.4 R 234.2	
S-240	0-6.4 Rock	2,500 18,800	G 239.1 R 232.7	
S-241	0-6.7 6.7-29.4 Rock	2,000 8,000 17,200	G 239.9 R 210.5	
S-242	0-8.3 Rock	3,300 17,600	G 239.4 R 231.1	
S-243	0-6.0 Rock	2,000 19,000	G 239.6 R 233.6	
S-244	0-6.3 6.3-37.3 Rock	1,870 8,000 18,600	G 239.2 R 201.9	
S-245	0-5.6 5.6-22.7 Rock	2,500 8,330 16,000	G 238.5 R 215.8	
S-246	0-9.1 9.1-52.5 Rock	1,670 7,600 17,500	G 250.2 R 197.7	
S-247	0-11.5 11.5-44.0 Rock	4,760 11,100 17,100	G 238.3 FR 226.8 R 194.3	
S-248	0-8.1 8.1-40.7 Rock	1,250 5,000 18,400	G 272.4 R 231.7	
S-249	0-5.2 5.2-37.5 Rock	2,000 6,600 17,000	G 236.9 R 199.4	

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Galop Island Channel				
S-250	0-5.6	3,300	G 236.6	
	5.6-34.4	7,400		
	Rock	17,000	R 202.2	
S-251	0-6.2	1,330	G 237.3	
	6.2-34.2	5,800		
	Rock	16,000	R 203.1	
S-252	0-5.6	2,000	G 245.6	
	5.6-36.9	7,900		
	Rock	17,100	R 208.7	
S-253	0-6.3	2,500	G 244.4	
	6.3-22.0	8,500		
	Rock	16,000	R 222.4	
S-254	0-8.0	1,540	G 257.3	
	8.0-38.5	6,250		
	Rock	16,400	R 218.8	
S-262	0-10.8	4,550	G 243.6	
	10.8-51.5	7,700		
	Rock	17,000	R 19[illegible].1	
S-263	0-5.3	2,500	G 242.[illegible]	
	5.3-40.0	8,350		
	Rock	17,000	R 202.5	
S-264	0-5.5	3,000	G 242.9	
	5.5-38.8	7,300		
	Rock	17,000	[illegible] 2[illegible].1	
S-265	0-6.2	1,250	G 246.9	
	6.2-55.7	8,100		
	Rock	17,000	R 191.2	
S-270	0-28.0	5,000	G 237.7	
	Rock	17,800	R 209.7	
S-271	0-15.0	5,000	G 236.8	
	Rock	17,800	R 221.8	
S-272	0-10.	5,000	G 236.4	
	10-37.0	7,500		
	Rock	16,500	R 199.4	
S-273	-27.5	5,000	G 238.9	
	Rock	17,000	R 211.4	
S-274	0-29.0	6,670	G 240.4	
	Rock	17,000	R 211.4	
S-275	0-36.4	8,000	G 237.4	
	Rock	17,000	R 201.0	
S-276	0-32.0	5,260	G 238.4	
	Rock	16,000	R 206.4	
S-277	0-27.7	5,260	G 239.4	
	Rock	17,500	R 211.7	
S-278	0-20.1	5,250	G 232.3	
	Rock	16,000	R 212.2	
S-279	0-11.9	5,000	G 233.3	
	Rock	16,000	R 221.4	
S-280	0-17.6	5,700	G 230.3	
	Rock	16,000	R 212.7	
S-281	0-14.5	5,000	G [illegible]33.3	
	Rock	16,000	R 218.8	
S-282	0-36.6	6,670	G 231.9	
	Rock	16,000	R 195.3	
S-283	0-15.4	5,500	G 286.7	
	Rock	16,000	R 211.3	
S-284	0-13.2	5,000	G 230.7	
	Rock	16,000	R 217.5	
S-285	0-10.7	8,350	G 230.0	
	Rock	17,400	R 219.[illegible]	
S-286	0-8.3	?	G 2[illegible].8	
	Rock	17,300	R 221.5	
S-287	0-3.0	10,000	G 230.0	
	Rock	16,200	R 227.0	
S-288	0-16.0	5,100	G 230.5	
	Rock	16,000	R 214.5	
S-289	0-27.0	5,000	G 230.5	
	Rock	16,000	R 203.5	
S-290	0-5.3	5,000	G 233.5	
	Rock	17,500	R 228.2	
S-291	0-2.6	5,000	G 229.6	
	Rock	16,000	R 227.0	
S-292	0-11.2	5,000	G 234.7	
	Rock	17,500	R 223.5	
S-349	0-5.8	1,430	G 243.5	
	5.8-41.6	7,000		
	Rock	16,600	R 203.9	
S-350	0-6.3	1,670	G 248.7	
	6.3-38.2	7,000		
	Rock	16,600	R 210.5	
Galop Island Channel (Cont'd)				
S-351	0-8.3	2,000	G 256.7	
	8.3-55.7	6,670		
	Rock	16,600	R 201.0	
S-352	0-7.0	1,250	G 258.3	
	7.0-68.0	7,500		
	Rock	16,600	R 190.3	
S-353	0-6.2	1,430	G 274.3	
	6.2-74.7	5,000		
	Rock	16,600	R 199.6	
S-354	0-7.5	1,670	G 259.1	
	7.5-20.0	5,000		
	20.0-53.2	7,300		
	Rock	16,600	R 205.9	
S-355	0-11.3	2,000	G 256.8	
	11.3-70.3	8,500		
	Rock	16,[illegible]00	R 186.5	
S-356	0-7.9	1,670	G 255.1	
	7.9-37.8	6,150		
	Rock	16,900	R 217.3	
S-357	0-6.8	1,250	G 260.3	
	6.8-33.0	5,000		
	Rock	16,[illegible]	R 227.3	
S-358	0-5.8	1,250	G 254.5	
	5.8-52.5	7,150		
	Rock	16,600	R 202.0	
S-359	0-5.7	1,430	G 265.9	
	5.7-19.1	3,700		
	19.1-74.0	7,500		
	Rock	16,900	R 191.9	
S-360	0-8.6	1,820	G 266.6	
	8.6-29.9	6,500		
	29.9-70.7	9,000		
	Rock	16,700	R 195.9	
S-361	0-7.9	1,670	G 261.6	
	7.9-73.4	7,150		
	Rock	16,600	R 188.2	
S-362	0-8.3	1,430	G 261.0	
	8.3-70.3	6,350		
	Rock	16,600	R 190.7	
S-363	0-6.1	1,670	G 246.7	
	6.1-31.5	7,800		
	Rock	17,100	R 215.2	
S-364	0-5.7	1,670	G 247.1	
	5.7-27.8	7,900		
	Rock	17,500	R 219.3	
S-365	0-6.3	1,670	G 253.7	
	6.3-36.3	5,400		
	Rock	16,600	R 222.4	
S-366	0-5.6	1,670	G 256.7	
	5.6-20.2	5,000		
	20.2-67.0	8,000		
	Rock	16,300	R 189.7	
S-367	0-6.5	1,670	G 258.7	
	6.5-21.6	4,000		
	21.6-78.9	8,000		
	Rock	16,900	R 179.8	
S-368	0-5.6	1,430	G 265.3	
	5.6-25.7	4,000		
	25.7-79.2	8,000		
	Rock	17,000	R 186.1	
S-369	0-7.2	1,670	G 259.3	
	7.2-36.0	5,000		
	Rock	17,000	R 233.3	
S-370	0-5.4	1,670	G 260.7	
	5.4-38.0	5,000		
	Rock	18,400	R 222.7	
S-371	0-6.4	1,250	G 250.3	
	6.4-33.8	5,[illegible]00		
	Rock	17,500	R 216.5	
S-372	0-7.1	1,670	G 257.3	
	7.1-40.1	6,100		
	Rock	16,300	R 217.2	
S-373	0-6.2	1,6[illegible]	G 253.7	
	6.2-[illegible]	6,670		
	Rock	16,[illegible]	R 215.4	
S-374	0-7.3	1,[illegible]	G 272.5	
	7.3-30.4	7,[illegible]00		
	Rock	16,600	R 242.1	
S-375	0-7.1	1,430	G 280.1	
	7.1-37.1	4,150		
	Rock	16,200	R 243.0	
S-376	0-10.2	4,000	G 244.0	
	Rock	17,600	R 233.8	

Note: WS-= Water surface
G = Ground surface
R = Rock surface
FR = Fractured rock

File NO. S-A-2/38
Sheet 2 of 8

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Galop Island Channel				
S-377	0-6.2	1,250	G 257.8	
	6.2-16.4	5,000		
	16.4-53.6	8,300		
	Rock	17,000	R 204.2	
S-378	0-6.8	1,250	G 277.6	
	6.8-33.6	5,350		
	Rock	17,800	R 244.0	
S-379	0-16.5	1,250	G 269.9	
	16.5-26.2	5,000		
	Rock	17,500	R 243.7	
S-380	0-7.6	1,000	G 271.0	
	7.6-40.4	6,100		
	Rock	16,600	R 230.6	
Lalone Island				
S-187	0-6.0	1,050	G 253.0	Data on all lines are satisfactory. Lines S-189, S-190, S-191, & S-208 indicated a compact dense overburden (apparently glacial till), while lines S-193, S-207 indicated either a soft or loose material. Bedrock varies from considerably below to well above grade.
	6.0-33.4	3,270		
	Rock	15,100	R 219.6	
S-188	0-8.0	1,360	G 256.4	
	8.0-32.7	4,320		
	Rock	16,000	R 223.7	
S-189	0-7.3	1,290	G 260.8	
	7.3-59.1	6,150		
	Rock	17,700	R 201.7	
S-190	0-6.8	2,140	G 237.3	
	6.8-34.6	7,700		
	Rock	17,800	R 203.7	
S-191	0-7.8	1,330	G 254.5	
	7.8-39.5	6,660		
	Rock	16,000	R 215.0	
S-192	0-5.6	1,140	G 256.3	
	5.6-43.2	4,880		
	Rock	16,000	R 213.1	
S-193	0-5.5	1,330	G 260.2	
	5.5-44.1	4,080		
	Rock	16,000	R 216.1	
S-207	0-15.0	4,160	G 236.5	
	Rock	17,500	R 221.5	
S-208	0-9.2	1,500	G 257.2	
	9.2-33.6	6,170		
	Rock	16,800	R 223.6	
Lotus Island				
S-182			G 245.6	Data for lines S-183, S-185, and S-186 are satisfactory. No data for line S-182. Compact, dense overburden (probably glacial till) exists throughout area. Bedrock is well below grade of cut.
S-183	0-9.5	1,820	G 244.1	
	9.5-63.9	8,520		
	Rock	13,600	R 180.2	
S-185	0-8.4	1,250	G 246.6	
	8.4-55.7	7,610		
	Rock	17,100	R 190.0	
S-186	0-11.6	1,800	G 246.7	
	11.6-59.7	8,780		
	Rock	18,100	R 187.0	
Sparrowhawk Pt. Cut				
S-161	0-7.9	1,050	G 250.1	Data in this area are satisfactory or fair. Overburden is compact and dense in area explored and is probably glacial till. Bedrock is well below grade of cut.
	7.9-73.7	6,960		
	Rock	16,400	R 176.4	
S-162	0-6.5	1,330	G 238.4	
	6.5-60.2	6,450		
	Rock	17,000	R 178.2	
S-163	0-9.5	1,200	G 253.4	
	9.5-75.5	6,400		
	Rock	15,400	R 177.9	
Toussaints Island Channel				
S-194	0-6.6	1,250	G 240.1	All data are satisfactory. overburden consists of 15 to 20 feet of soft or loose material, underlain by compact dense overburden (probably galcial till). Bedrock is well below grade and was not reached by any line.
	6.6-17.6	5,000		
	17.6-71.9	8,140		
	Rock below 168.2			
S-195	0-6.1	1,670	G 235.7	
	6.1-17.6	4,000		
	17.6-79.0	8,030		
	Rock below		156.7	
S-196	0-5.3	1,540	G 249.4	
	5.3-16.3	4,000		
	16.3-74.6	8,030		
		Rock below	174.8	
S-197	0-5.0	1,330	G 250.3	
	5.0-16.4	4,000		
	16.4-66.6	7,450		
		Rock below	183.7	
S-198	0-5.2	1,670	G 244.4	
	5.2-14.5	4,000		
	14.5-85.1	7,900		
		Rock below	159.3	
Toussaints Island Channel (Cont'd)				
S-199	0-4.8	1,540	G 239.0	
	4.8-18.4	4,000		
	18.4-84.4	8,550		
		Rock below	154.6	
Iroquois Dam Site				
S-44	0-17.2	5,000	G 229.2	Data for lines considered either satisfactory or fair. Overburden in the explored area is generally compact and dense, however, line S-48, and S-55 indicated that either a soft or loose material was present. The elevation of bedrock varies considerably throughout the site.
	Rock	15,300	R 212.0	
S-45	0-28.2	5,000	G 229.0	
	Rock	17,000	R 200.8	
S-46	0-5.0	2,500	G 230.2	
	5.0-59.2	9,200		
	Rock	12,900	R 171.0	
S-47	0-8.0	3,750	G 229.9	
	8.0-59.9	8,390		
	Rock	17,800	R 170.0	
S-48	0-6.5	1,210	G 245.7	
	6.5-25.5	4,200		
	25.5-70.7	7,510		
	Rock	16,500	R 175.0	
S-49	0-3.3	1,335	G 268.7	
	3.3-76.0	4,680		
	Rock	17,600	R 192.7	
S-51	0-8.9	1,050	G 241.1	
	8.9-55.5	6,200		
	Rock	14,700	R 185.6	
S-52	0-12.0	1,500	G 257.4	
	12.0-90.1	8,000		
	Rock	16,000	R 167.3	
S-55	0-7.1	800	G 266.3	
	7.1--62.6	4,950		
	Rock	14,600	R 203.7	
S-91	0-6.0	1,870	G 233.5	
	6.0-38.3	8,890		
	Rock	17,400	R 195.2	
S-297	0-8.2	2,000	G 232.6	
	8.2-64.5	7,800		
	Rock	18,000	R 168.1	
S-298	0-5.7	2,250	G 230.5	
	5.7-36.2	7,000		
	Rock	18,000	R 194.3	
S-299	0-5.5	1,430	G 233.5	
	5.5-31.6	7,000		
	Rock	18,000	R 201.9	
S-300	0-8.0	1,430	G 239.1	
	8.0-50.0	6,700		
	Rock	18,000	R 189.1	
S-301	0-7.3	1,250	G 238.6	
	7.3-35.3	7,500		
	Rock	17,500	R 203.3	
S-302	0-8.9	1,250	G 259.0	
	8.9-88.4	7,000		
	Rock	17,500	R 170.6	
S-303	0-9.7	1,000	G 266.0	
	9.7-66.5	5,270		
	Rock	17,500	R 199.5	
S-334	0-6.7	2,500	G 229.8	
	6.7-60.8	7,900		
	Rock	17,500	R 169.0	
Point Rockway Canal				
S-50	0-6.8	2,860	G 231.5	Data in the Rockway Canal are considered satisfactory or fair. Due to the overburden and bedrock conditions in some sections explored, the interpretation of the results in these areas is uncertain. (See report for discussion.) The results indicate that the overburden generally is either soft or loose material. Occasional areas of compact, dense material is indicated. The elevation of bedrock varies from well above grade to well below grade along the canal.
	6.8-25.0	8,000		
	Rock	17,500	R 206.5	
S-53	0-6.3	1,000	G 241.6	
	6.3-26.6	6,150		
	Rock	17,000	R 215.0	
S-54	0-6.0	3,330	G 232.4	
	6.0-25.4	7,300		
	Rock	17,000	R 207.0	
S-88	0-3.9	1,820	G 228.5	
	3.9-26.8	5,500		
	Rock	16,000	R 201.7	
S-89	0-30.1	4,000	G 229.5	
	Rock	17,800	R 199.4	
S-90	0-16.2	3,570	G 230.3	
	16.2-34.8	8,380		
	Rock	16,700	R 195.5	
S-97	0-3.2	3,330	G 233.2	
	3.2-33.6	5,065		
	Rock	16,200	R 199.6	
S-114	0-39.0	5,000	G 240.1	
	Rock	17,100	R 201.1	
S-115	0-15.5	4,000	G 241.5	
	Rock	15,400	R 226.0	
S-116	0-6.3	3,330	G 235.8	
	6.3-56.7	5,290		
	Rock	16,400	R 179.1	

Note: WS - Water surface
G - Ground surface
R - Rock surface
FR - Fractured rock

File No. S-A-2/39
Sheet 3 of 8

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Point Rockway Canal (Cont'd)				
S-164	0-5.2	1,330	G 223.0	
	5.2-21.1	5,940		
	Rock	17,100	R 206.9	
S-165	0-4.8	1,250	G 246.7	
	4.8-39.7	4,380		
	Rock	18,000	R 207.0	
S-166	0-6.7	1,430	G 234.7	
	6.7-23.5	5,330		
	Rock	15,100	R 211.2	
S-167	0-6.1	1,330	G 244.5	
	6.1-36.7	4,000		
	Rock	17,300	R 207.8	
S-168	0-11.3	1,500	G 268.3	
	11.3-76.0	5,460		
	Rock	17,200	R 192.3	
S-169	0-4.3	1,500	G 233.4	
	4.3-37.9	5,000		
	Rock	17,100	R 195.5	
S-170	0-6.1	2,220	G 233.1	
	6.1-32.5	5,720		
	Rock	18,800	R 200.6	
S-171	0-5.7	1,250	G 241.7	
	5.7-21.4	4,640		
	Rock	16,800	R 220.3	
S-172	0-5.8	2,500	G 237.1	
	5.8-25.3	5,520		
	Rock	17,530	R 211.8	
S-173	0-5.4	1,500	G 236.0	
	5.4-13.3	5,000		
	Rock	16,300	R 222.7	
S-174	0-5.4	1,870	G 243.8	
	5.4-36.9	6,250		
	Rock	18,500	R 206.9	
S-175	0-9.0	2,070	G 241.1	
	Rock	16,100	R 232.1	
S-176	0-5.3	2,000	G 239.8	
	5.3-20.3	5,000	FR 234.5*	
	Rock	17,400	R 219.5	
S-177	0-3.1	2,000	G 231.5	
	3.1-18.6	5,400		
	Rock	18,800	R 212.9	
S-178	0-5.3	2,000	G 234.4	
	5.3-30.3	5,000		
	Rock	17,300	R 204.1	
S-179	0-4.5	2,220	G 234.8	
	4.5-12.4	5,000		
	Rock	17,600	R 222.4	
S-209	0-3.9	1,875	G 231.9	
	3.9-27.3	6,670		
	Rock	18,000	R 204.6	
S-210	0-4.6	1,670	G 232.6	
	4.6-28.2	5,900		
	Rock	16,250	R 204.4	
S-211	0-5.7	1,000	G 247.0	
	5.7-34.0	4,820		
	Rock	17,300	R 213.0	
S-212	0-4.7	2,720	G 233.0	
	4.7-22.8	5,000		
	Rock	16,700	R 210.2	
S-213	0-6.0	1,430	G 238.0	
	6.0-34.2	5,000		
	Rock	16,850	R 203.8	
S-214	0-5.0	1,670	G 245.0	
	5.0-18.8	5,000		
	Rock	17,300	R 226.2	
S-315	0-6.4	2,000	G 237.0	
	6.4-28.8	5,000		
	Rock	16,250	R 208.2	
S-316	0-6.4	2,000	G 239.9	
	6.4-29.4	5,000		
	Rock	16,200	R 210.5	
S-317	0-5.9	2,000	G 239.4	
	5.9-21.0	5,000		
	Rock	16,250	R 218.4	
S-318	0-8.0	1,670	G 240.1	
	8.0-30.4	5,000		
	Rock	16,250	R 209.7	
S-319	0-7.0	1,670	G 237.9	
	7.0-13.6	5,000	FR 230.9	
	Rock	16,250	R 224.3	
S-320	0-5.4	1,670	G 237.1	
	5.4-14.6	5,000	FR 231.7	
	Rock	16,250	R 222.5	
S-321	0-6.5	1,250	G 235.3	
	6.5-36.8	5,000		
	Rock	16,250	R 198.5	
S-322	0-5.[illegible]	2,500	G 238.2	
	Rock	16,250	R 232.4	
S-323	0-4.3	2,000	G 244.6	
	4.3-20.7	5,000	FR 240.3	
	Rock	16,250	R 223.9	
S-324	0-5.8	1,430	G 234.3	
	5.8-16.3	5,000		
	Rock	16,250	R 218.0	
S-325	0-6.7	2,500	G 233.2	
	Rock	16,250	R 226.5	
S-326	0-6.0	2,500	G 230.1	
	Rock	16,250	FR 229.5	
			R 224.1	
S-327	0-8.6	2,500	G 238.8	
	Rock	16,250	R 230.2	
S-328	0-10.5	2,500	G 233.6	
	Rock	16,250	R 223.1	
S-329	0-4.5	1,670	G 233.3	
	4.5-16.3	5,000		
	Rock	16,250	R 217.0	
S-330	0-7.8	1,670	G 238.2	
	7.8-23.2	8,350		
	Rock	17,500	R 215.0	
S-331	0-6.6	1,000	G 236.7	
	6.6-22.8	5,000		
	Rock	17,500	R 213.9	
S-332	0-5.1	1,430	G 235.1	
	5.1-22.2	5,000		
	Rock	17,500	R 212.9	
S-333	0-5.4	1,670	G 231.8	
	5.4-23.2	5,000		
	Rock	17,500	R 208.6	
S-381	0-9.8	1,250	G 237.6	
	9.8-46.4	9,000		
	Rock	17,500	R 191.2	
S-392	0-8.5	5,000	G 225.1	
	8.5-45.1	9,000		
	Rock	17,500	R 180.0	
Point Three Points				
S-92	0-5.2	1,665	G 236.5	Data are satisfactory or fair. Overburden is indicated to be a fairly compact to compact material (probably glacial till). Bedrock is below the grade of cut.
	5.2-56.7	5,060		
	Rock	16,900	R 179.8	
S-93	0-6.5	1,430	G 235.7	
	6. 5-45.1	5,000		
	Rock	15,750	R 190.6	
S-94	0-9.2	1,500	G 247.7	
	9.2-56.2	6,000		
	Rock	16,300	R 191.5	
S-95	0-7.3	2,000	G 235.6	
	7.3-61.8	5,950		
	Rock	15,800	R 173.8	
S-96	0-10.0	2,220	G 246.1	
	10.0-71.5	6,650		
	Rock	17,200	R 174.6	
S-77	0-22.4	3,330	G 234.4	
	Rock	16,000	R 212.0	
S-78	0-7.2	1,500	G 237.2	
	7.2-43.8	6,270		
	Rock	16,000	R 193.4	
S-79	0-6.8	1,050	G 243.7	
	6.8-38.1	5,600		
	Rock	17,900	R 205.6	
Leishmans Point				
S-124	0-35.7		G 238.8	Data for all lines are either satisfactory or fair. This area has been divided into two sections for discussion. 1. South Cut--The overburden is variable in this area and the results indicate that both soft or loose material and compact dense material will be encountered. Bedrock is generally well below grade but may be slightly above grade at the extreme eastern end of the cut. 2. Middle Cut--Overburden is compact and dense (probably glacial till). Bedrock is below grade. Owing to frost conditions lines S-124, S-125, and S-127 did not contribute to the knowledge of the character of the overburden, however, the rock elevations given are believed to be fairly reliable.
	Rock	16,600	R 203.1	
S-125	0-30.6		G 234.5	
	Rock	15,800	R 203.9	
S-126	0-9.9	1,540	G 244.7	
	9.9-43.6	6,130		
	Rock	16,600	R 201.1	
S-309	0-7.6	2,940	G 225.6	
	Rock	17,650	R 218.0	
S-310	0-6.2	2,940	G 226.1	
	6.2-19.2	8,300		
	Rock	18,100	R 206.9	
S-311	0-6.0	1,670	G 232.2	
	6.0-40.0	4,500		
	Rock	17,000	R 192.2	
S-312	0-4.7	2,000	G 225.8	
	4.7-26.5	6,660		
	Rock	17,000	R 199.3	
S-127	0-44.5		G 244.7	
	Rock	17,500	R 200.2	

Note: WS = Water surface
G = Ground surface
R = Rock surface
FR = Fractured rock

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Leishmans Point (Cont'd)				
S-313	0-7.3	2,500	G 225.6	
	7.3-32.6	8,100		
	Rock	17,000	R 193.0	
S-314	0-5.6	1,670	G 225.9	
	5.6-28.6	8,100		
	Rock	17,000	R 197.3	
Ogden Island				
S-70	0-5.5	1,110	G 245.7	Data is all satisfactory or fair. This group of lines has been divided into 5 sections for discussion. 1. Middle Cut--overburden may vary from soft or loose material to compact, dense material (probably glacial till). Bedrock is generally below grade but is apparently above grade at the western end of the cut. 2. West Cut--Overburden may vary from soft or loose material to compact, dense material (probably glacial till) Bedrock is below grade. 3. East Cut--Overburden is compact and dense (probably glacial till). Bedrock is below grade. 4. Waddinton Cut--Overburden is probably quite variable throughout. Bedrock is apparently above grade in the north west section of the cut but is below grade in the other sections explored. 5. Little River Cut--Overburden varies from loose to compact material. Bedrock is apparently above grade along New York mainland area which was the only section explored
	5.5-51.5	3,630		
	Rock	16,900	R 194.2	
S-71	0-7.8	1,110	G 247.3	
	7.8-25.6	6,650		
	Rock	15,000	R 221.7	
S-72	0-12.5	2,000	G 262.5	
	12.5-60.3	5,000		
	Rock	14,700	R 202.2	
S-73	0-3.0	1,670	G 242.7	
	3.0-45.4	4,100		
	Rock	15,300	R 197.3	
S-74	0-12.0	2,850	G 232.1	
	12.0-53.0	8,600		
	Rock	16,900	R 179.1	
S-75	0-4.9	1,540	G 229.0	
	4.9-46.6	7,000		
	Rock	16,000	R 182.4	
S-76	0-6.9	1,500	G 236.7	
	6.9-37.8	4,380		
	Rock	16,000	R 198.9	
S-80	0-7.0	1,250	G 228.9	
	7.0-60.0	7,150		
	Rock	16,000	R 168.9	
S-81	0-8.0	1,540	G 239.1	
	8.0-69.3	6,350		
	Rock	14,300	R 169.8	
S-82	0-9.7	2,000	G 245.6	
	9.7-60.8	5,900		
	Rock	14,500	R 184.8	
S-83	0-6.1	1,500	G 232.6	
	6.1-41.0	6,400		
	Rock	16,200	R 191.6	
S-84	0-4.2	1,500	G 230.1	
	4.2-36.4	7,000		
	Rock	18,000	R 193.7	
S-85	0-7.7	1,500	G 230.5	
	7.7-55.3	5,900		
	Rock	16,600	R 175.2	
S-86	0-6.5	1,250	G 232.2	
	6.5-22.7	5,150		
	Rock	15,900	R 209.5	
S-87	0-7.7	1,500	G 231.6	
	7.7-52.7	6,150		
	Rock	16,100	R 178.9	
S-117	0-22.2	2,860	G 234.9	
	Rock	14,900	R 212.7	
S-118	0-28.5		G 235.5	
	Rock	16,900	R 207.0	
S-119	0-28.1	4,000	G 235.1	
	Rock	16,500	R 207.0	
S-122	0-18.0	2,860	G 235.5	
	Rock	16,400	R 217.5	
S-123	0-7.4	1,670	G 238.4	
	7.4-45.5	5,000		
	Rock	15,700	R 192.9	
S-149	0-8.3	1,670	G 234.0	
	Rock	16,800	R 225.7	
S-150	0-6.6	1,110	G 255.4	
	6.6-41.2	5,630		
	Rock	14,750	R 214.2	
S-154	Test line on ice.			
Louisville Landing and Bradford Point Dikes				
S-382	0-6.7	1,250		All data are satisfactory. Lines S-382, S-383, & S-384 were fired off location and were never located. 1. Bradford Dike--Rock is deeply buried and the overburden is apparently soft or loose to rock except near line S-387 where firm material is approximately 20 feet deep. 2. Louisville Dikes--Rock is deeply buried and the overburden is apparently firm except near line S-420 where there is approximately 20 feet of soft or loose material overlying firm material.
	6.7-35.2	4,350		
	35.2-101.7	7,900		
S-383	0-6.0	1,250		
	6.0-26.5	5,000		
	26.5-106.2	7,350		
S-384	0-4.8	1,430		
	4.8-15.8	3,800		
	15.8-105.6	7,600		

Note: WS = Water surface
G = Ground surface
R = Rock surface
FR = Fractured rock

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Louisville Landing & Bradford Dikes (Cont'd)				
S-385	0-6.4	2,000	G 241.6	
	6.4-70.4	5,000		
	Rock	17,500	R 171.2	
S-386	0-9.9	2,000	G 243.4	
	9.9-92.9	5,000		
	Rock	17,500	R 150.5	
S-387	0-7.5	2,000	G 267.6	
	7.5-20.0	5,000		
	Rock	17,500	R 161.3	
S-420	0-5.1	740	G 235.4	
	5.1-20.5	4,500		
	20.5-88.3	7,500		
	Rock	16,000	R 147.1	
S-421	0-6.6	2,500	G 219.7	
	6.6-69.8	6,580		
		Rock below	149.9	
S-422	0-9.2	1,820	G 238.4	
	9.2-94.9	6,150		
	Rock	16,000	R 143.5	
Massena Canal Intake Works				
S-28	Data erratic		G-242.0	Only lines S-29, S-160, S-158, S-266, S-267 & S-268 are considered satisfactory or fair. The other lines were unsatisfactory because the data was erratic due to artifical fill and frost. The overburden is apparently fairly compact to compact, dense material (probably glacial till). Bedrock is fairly close to the lower grade but a rock cut is not expected.
S-29	0-9.3	1,820	G 231.9	
	9.3-69.4	7,500		
	Rock	17,900	R 162.5	
S-30	No data		G 220.8	
S-31	Data erratic		G 227.5	
S-32	Data erratic		G 225.9	
S-121	Data erratic--frost		G 242.9	
S-155	Data erratic--fill		G 222.0	
S-156	Data erratic--fill		G 234.0	
S-157	Data erratic--fill		G 234.7	
S-158	0-6.9	1,670	G 218.4	
	6.9-41.6	6,680		
	Rock	16,400	R 176.8	
S-159	Data erratic--fill		G 228.4	
S-160	0-9.4	1,330	G 227.8	
	9.4-55.9	6,270		
	Rock	19,700	R 171.9	
S-266	0-7.1	1,670	G 225.9	
	7.1-55.1	7,000		
	Rock	17,200	R 170.8	
S-267	0-8.5	1,250	G 227.4	
	8.5-57.3	7,000		
	Rock	20,000	R 170.1	
S-268	0-9.0	1,670	G 222.4	
	9.0-53.0	6,500		
	Rock	17,500	R 169.4	
S-269	Data erratic--fill		G 234.1	
Cut "F" Long Sault Island				
S-16	0-7.6	1,250	G 227.6	All data are satisfactory or fair except line S-20 where data was not obtained. Lines S-395 to S-400 inclusive were shot off location and are not discussed. overburden is generally compact and dense (probably glacial till). except for superficial deposits of soft or loose material in some areas. Bedrock is generally below grade in the area of the cut but in one small area it was indicated that bedrock would be above grade.
	7.6-49.0	6,400		
	Rock	17,800	R 178.6	
S-17	0-5.8	1,180	G 233.3	
	5.8-44.2	5,800		
	Rock	15,600	R 189.1	
S-18	0-13.3	1,580	G 271.4	
	13.3-87.2	7,560		
	Rock	16,000	R 184.2	
S-19	0-10.1	1,820	G 249.4	
	10.1-81.8	7,360		
	Rock	16,900	R 167.6	
S-20	No data		G 262.0	
S-21	0-13.6	1,200	G 222.7	
	13.6-53.8	6,360		
	Rock	14,400	R 168.9	
S-22	0-8.8	910	G 225.7	
	8.8-62.7	7,500		
	Rock	20,000	R 163.0	
S-57	0-13.3	770	G 217.7	
	13.3-47.7	4,100		
	Rock	16,800	R 170.0	
S-58	0-8.7	1,430	G 224.0	
	8.7-47.3	5,400		
	Rock	14,000	R 176.7	
S-59	0-7.6	1,000	G 217.7	
	7.6-54.9	7,000		
	Rock	17,900	R 162.8	
S-393	0-6.6	3,330	G 183.4	
	6.6-23.6	7,200		
	Rock	16,600	R 159.8	

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Cut "F" Long Sault Island (Cont'd)				
S-394	0-5.0	2,500	G 182.0	
	5.0-22.7	7,150		
	Rock	17,500	R 159.3	
S-395	0-11.4	1,000		
	11.4-57.7	6,200		
	Rock	16,600		
S-396	0-4.6	2,500		
	4.6-41.6	5,000		
	Rock	16,000		
S-397	0-4.5	1,100		
	4.5-53.1	4,550		
	Rock	16,600		
S-398	0-7.8	1,000		
	7.8-55.2	4,600		
	Rock	16,600		
S-399	0-6.1	1,000		
	6.1-57.1	5,000		
	Rock	16,700		
S-400	0-5.5	1,250		
	5.5-62.2	4,850		
	Rock	17,000		
S-401	0-6.1	1,250	G 221.1	
	6.1-49.6	6,670		
	Rock	17,000	R 171.5	
S-402	0-11.1	1,250	G 219.4	
	11.1-53.5	6,458		
	Rock	17,500	R 165.9	
S-403	0-3.2	2,500	G 197.1	
	3.2-28.0	5,000		
	Rock	17,500	R 169.1	
S-404	0-7.6	1,670	G 245.8	
	7.6-25.8	5,000		
	25.8-76.9	6,670		
	Rock	17,000	R 168.9	
S-405	0-5.1	1,670	G 249.4	
	5.1-17.6	3,950		
	17.6-89.3	7,150		
	Rock	17,000	R 160.1	
S-406	0-6.4	1,670	G 257.9	
	6.4-16.4	4,300		
	16.4-91.7	7,150		
	Rock	17,000	R 165.2	
S-407	0-11.2	2,200	G 260.8	
	11.2-85.7	6,900		
	Rock	17,000	R 175.1	
S-408	0-4.8	1,670	G 249.0	
	4.8-16.4	3,450		
	16.4-72.4	6,900		
	Rock	17,000	R 176.6	
S-409	0-4.8	1,670	G 260.1	
	4.8-17.2	3,330		
	17.2-92.1	7,150		
	Rock	17,000	R 168.0	
S-410	0-11.7	4,150	G 182.7	
	Rock	17,500	R 171.0	
S-411	0-11.6	4,550	G 180.9	
	Rock	17,500	R 169.3	
S-412	0-6.4	1,670	G 257.5	
	6.4-17.7	4,550		
	17.7-77.5	6,900		
	Rock	17,500	R 180.0	
Long Sault Canal				
S-23	No data		G 228.0	Of the 54 lines fired in the canal 15 were satisfactory and 9 were fair while the other 30 were either unsatisfactory or no data at all was obtained. The satisfactory or fair lines are S-24, S-25, S-56, S-60-S-69 inclusive, S-98, S-99, S-101-104 inclusive, S-107, S-111, S-141. S-148, and S-151. The seismic results showed that overburden materials in the canal area varied from soft or loose material to compact, dense material. As most of the lines in this area were fired during cold weather, the interpretation of overburden conditions on most of the lines is not warranted. Bedrock elevations obtained from satisfactory or fair lines are believed to be fairly reliable in most instances. Some errors may have been made because of the effect of the frost conditions on the records
S-24	0-9.7	1,670	G 224.7	
	9.7-57.5	4,520		
	Rock	17,000	R 167.2	
S-25	0-8.5	1,670	G 202.4	
	8.5-46.3	5,820		
	Rock	17,800	R 156.1	
S-43	No data		G 229.2	
S-56	0-4.2	1,000	G 221.5	
	4.2-51.2	4,220		
	Rock	16,600	R 170.3	
S-60	0-4.6	1,250	G 254.3	
	4.6-95.1	7,100		
	Rock	12,800	R 159.2	
S-61	0-5.5	1,250	G 238.9	
	5.5-89.0	6,470		
	Rock	16,100	R 149.9	
S-62	0-61	910	G 245.0	
	61-87.0	7,200		
	Rock	17,800	R 158.0	

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Long Sault Canal (Cont'd)				
S-63	0-6.0	910	G 250.2	
	6.0-98.0	6,700		
	Rock	16,900	R 152.2	
S-64	0-7.5	1,330	G 245.0	
	7.5-90	7,350	FR 155.0	
S-65	0-8.0	2,220	G 181.5	
	8.0-54.5	4,300		
	Rock	16,000	R 127.0	
S-66	0-8.7	940	G 184.0	
	8.7-25.9	4,000		
	25.9-74.3	6,000		
	Rock	14,500	R 109.7	
S-67	0-12.0	2,220	G 221.4	
	12.0-82.4	7,200		
	Rock	17,300	R 139.0	
S-68	0-7.0	1,250	G 199.7	
	7.0-65.2	4,440		
	Rock	16,000	R 134.5	
S-69	0-4.6	2,000	G 188.9	
	4.6-61.4	4,500		
	Rock	16,400	R 127.5	
S-98	0-10.4	2,000	G 233.7	
	10.4-88.6	6,830		
	Rock	18,400	R 145.1	
S-99	0-8.2	1,870	G 237.9	
	8.2-86.4	6,560		
	Rock	17,300	R 151.5	
S-100	Data erratic--frost		G 202.7	
S-101	0-4.5	2,670	G 231.7	
	4.5-100	6,500		
		Rock below	131.7	
S-102	0-4.7	2,860	G 230.8	
	4.7-37.9	5,770		
	37.9-110	7,450		
		Rock below	120.8	
S-103	0-5.2	2,350	G 226.3	
	5.2-50.8	4,930		
	Rock	16,900	R 175.5	
S-104	0-6.2	1,500	G 216.0	
	6.2-65.0	5,000		
	Rock	15,400	R 151.0	
S-105	No data		G 184.1	
S-106	Data erratic--frost		G 205.3	
S-107	0-17.5	3,080	G 235.7	
	17.5-102	7,450		
		Rock below	133.7	
S-108	Data erratic--frost		G 254.3	
S-109	No data		G 247.6	
S-110	No data		G 208.0	
S-111	0-2.7	1,250	G 200.7	
	2.7-46.0	4,640		
	Rock	15,000	R 154.7	
S-120	Data erratic--frost		G 198.8	
S-128	Data erratic--frost		G 184.0	
S-129	Data erratic--frost		G 187.8	
S-130	No data		G 188.8	
S-131	Data erratic--frost		G 193.6	
S-132	No data		G 185.9	
S-133	No data		G 189.5	
S-134	Data erratic--frost		G 195.6	
S-135	Data erratic--frost		G 196.4	
S-136	Data erratic--frost		G 176.0	
S-137	Data erratic--frost		G 180.0	
S-138	Data erratic--frost		G 196.7	
S-139	No data		G 196.8	
S-140	No data		G 203.3	
S-141	0-7.2	2,860	G 188.7	
	7.2-83.4	6,000		
	Rock	17,300	R 105.3	
S-142	No data		G 197.4	
S-143	Data erratic--frost		G 204.1	
S-144	Data erratic--frost		G 200.7	
S-145	Data erratic--frost		G 201.6	
S-146	Data erratic--frost		G 220.8	

Note: WS = Water surface
G = Ground surface
R = Rock surface
FR = Fractured rock

File No. S-442/43
Sheet 6 of 8

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden In Feet	Overburden and Rock Velocities	Elevations	Interpretations
Long Sault Canal (Cont'd)				
S-147	Data erratic--frost		G 186.4	
S-148	0-9.4 9.4-105.2 Rock	2,500 6,440 16,400	G 202.9 R 97.7	
S-151	0-7.9 7.9-73.4 Rock	1,250 7,000 16,000	G 226.9 R 153.5	
S-152	No data		G 205.5	
S-153	No data		G 198.7	
Long Sault Dam				
S-1	0-34.3 Rock	4,330 20,000	G 174.5 R 140.2	Data are satisfactory or fair except for line S-6 and singl shot determination SS-3677. The results of all satisfactory or fair lines are believed to be reasonably reliable. See the report for reliability of single shot determinations. The overburden is apparently somewhat variable but generally is a fairly compact to compact material (probably glacial till). In various areas there are indicated small deposits of loose or soft material.
S-2	0-29.7 Rock	5,000 17,800	G 174.8 R 145.1	
S-3	0-24.1 Rock	5,000 16,800	G 176.0 R 151.9	
S-4	0-6.3 6.3-70.0 Rock	1,300 6,250 16,800	G 227.9 R 157.9	
S-5	0-6.7 6.7-89.4 Rock	1,430 6,200 16,400	G 238.1 R 148.7	
S-6	No data		G 179.2	
S-7	0-11.6 11.6-39.7 Rock	1,000 5,000 15,000	G 202.8 R 163.1	
S-8	0-15.4 Rock	4,440 17,300	G 173.5 R 158.1	
S-9	0-5.2 5.2-23.2 Rock	1,200 4,100 15,900	G 177.3 R 154.1	
S-10	0-6.0 6.0-21.9 21.9-62.5 Rock	1,400 3,500 6,200 16,000	G 214.9 R 152.4	
S-11	0-7.4 7.4-56.6 Rock	1,150 7,050 17,500	G 212.7 R 156.1	
S-12	0-8.0 8.0-52.5 Rock	1,250 7,000 16,700	G 212.5 R 160.0	
S-13	0-5.8 5.8-54.9 Rock	1,250 6,250 17,000	G 212.2 R 157.3	
S-14	0-8.9 Rock	3,860 15,650	G 172.2 R 163.3	
S-15	0-7.9 Rock	2,500 15,950	G 172.9 R 165.0	
S-42	0-7.8 7.8-97.0 Rock	1,430 7,100 16,000	G 245.2 R 148.2	
S-112	0-8.6 8.6-119.4	1,500 7,800 Rock below	G 271.3 151.9	
S-113	0-7.4 7.4-105.0 Rock	1,180 7,210 16,950	G 252.5 R 147.5	
S-413	0-9.3 9.3-43.3 Rock	1,430 5,000 16,600	G 204.5 R 161.2	
S-414	0-15.2 Rock		G 170.1 R 154.9	
S-415	0-8.1 Rock		G 158.1 R 150.1	
S-416	0-3.1 Rock		G 157.1 R 154.0	
S-417	0-19.0 Rock		G 157.1 R 138.1	
S-418	0-18.0 Rock		G 156.1 R 138.1	
SS-3674	11' of 0-13.4 Rock	Water	WS 173.1 G 162.1 R 148.7	
SS-3675	18' of 0-5.9 Rock	Water	WS 173.1 G 155.1 R 149.2	
SS-3676	15' of 0-4.9 Rock	Water	WS 173.1 G 158.1 R 153.2	
SS-3677	No data		WS 173.1 G 160.1	

Location and Line No.	Depth of overburden In Feet	Overburden and Rock Velocities	Elevations	Interpretations
Long Sault Dam (Cont'd)				
SS-3678	0-14.3 20' of Rock	 Water	G 153.1 WS 173.1 R 138.8	
SS-3679	15' of 0-10.0 Rock	Water	WS 173.1 G 158.0 R 148.0	
SS-3680	41' of 0-25.0 Rock	Water	WS 173.1 G 169.0 R 144.0	
Power House				
S-26	0-7.5 7.5-65/5 Rock	1,250 4,360 14,300	G 215.4 R 149.9	Data are all satisfactory or fair. Overburden is generally a compact dense material. The bedrock elevations determined are believed to be reasonably accurate.
S-27	0-14.3 14.3-63.7 Rock	1,360 6,000 14,700	G 202.5 R 138.8	
S-33	0-9.1 9.1-34.9 Rock	1,250 7,475 15,900	G 185.9 R 151.0	
S-34	0-6.8 6.8-43.6 Rock	2,000 7,750 15,700	G 185.6 R 142.0	
S-255	0-59.5 Rock	7,250 18,000	G 160.0 R 100.5	
S-256	0-11.6 11.6-78.6 Rock	1,430 6,700 18,000	G 190.6 R 112.0	
S-257	0-49.2 Rock	7,500 17,000	G 159.5 R 110.3	
S-258	0-9.3 9.3-48.3 Rock	4,550 8,100 17,600	G 159.1 R 110.8	
S-259	0-5.8 5.8-59.6 Rock	3,000 8,000 17,000	G 160.5 R 100.9	
S-260	0-5.9 5.9-52.2 Rock	3,000 7,700 17,000	G 159.8 R 107.6	
S-261	0-4.3 4.3-51.0 Rock	3,000 6,800 17,500	G 160.0 R 109.0	
New Cornwall Canal				
S-35	0-9.9 9.9-58.7 Rock	2,000 6,488 16,000	G 191.9 R 133.2	Data are all satisfactory or fair. Bedrock elevations are believed to be reasonably accurate. Overburden in the areas explored is generally compact, dense material (probably glacial till). The results of line S-39 are the most questionable regarding both overburden and bedrock.
S-36	0-13.5 13.5-48.8 Rock	2,150 7,650 11,000	G 204.5 R 155.7	
S-37	0-7.2 7.2-69.0 Rock	1,540 7,150 14,625	G 214.3 R 145.3	
S-38	0-7.2 7.2-47.4 Rock	1,430 5,110 14,800	G 211.8 R 164.4	
S-39	0-9.7 9.7-51.7 Rock	1,250 7,000 17,200	G 210.6 R 158.9	
S-40	0-7.7 7.7-47.8 Rock	742 6,536 17,600	G 209.8 R 162.0	
S-41	0-6.5 6.5-70.4 Rock	1,482 7,400 17,650	G 231.8 R 161.4	
Cornwall Island Cut				
S-180	0-9.3 9.3-40.6 Rock	1,430 6,260 13,900		Both lines are satisfactory. Overburden is apparently compact and dense. Depths to rock are believed to be reliable. Elevations are not given as lines were not surveyed.
S-181	0-6.0 6.0-46.0 Rock	1,250 5,910 14,300		
Racquette Pt. Channel				
S-293	0-4.8 4.8-52.6 Rock	3,330 7,000 17,500	G 153.8 R 101.2	Data are satisfactory. Overburden is apparently compact and dense (probably glacial till). Bedrock is generally below grade in the area explored.
S-294	0-8.3 8.3-97.8 Rock	1,667 7,000 18,000	G 194.7 R 96.9	
S-295	0-5.0 5.0-42.0 Rock	3,300 6,850 17,500	G 152.9 R 110.9	
S-296	0-8.5 8.5-91.0 Rock	1,820 6,900 18,000	G 192.3 R 101.3	

Note: WS = Water surface
G = Ground surface
R = Rock Surface
FR = Fractured rock

File No. S-A-2/42
Sheet 7 of 8

TABLE II

SEISMIC DATA & RESULTS

ST. LAWRENCE RIVER PROJECT

Location and Line No.	Depth of overburden in Feet	Overburden and Rock Velocities	Elevations	Interpretations
Racquette Pt. Channel (Cont'd)				
S-308	0-8.0	1,520	G 183.8	
	8.0-94.5	7,600		
	Rock	17,500	R 89.3	
R. R. Bridge, Power Canal				
S-304	0-5.3	1,250	G 212.3	The data for all lines are satisfactory. Elevations of bedrock are believed to be reasonably accurate. Overburden on the northeast side of the canal apparently consists of approximately 20 feet of soft or loose material overlying compact, dense material. On the southwest side of the canal the overburden is compact and dense.
	5.3-17.3	4,550		
	17.3-66.3	7,150		
	Rock	17,500	R 146.0	
S-305	0-6.5	1,250	G 211.3	
	6.5-25.8	4,700		
	25.8-71.5	8,800		
	Rock	17,500	R 139.8	
S-306	0-13.3	4,550	G 199.9	
	13.3-54.7	8,160		
	Rock	17,500	R 145.2	
S-307	0-13.7	4,350	G 200.2	
	13.7-52.7	8,350		
	Rock	18,000	R 147.5	
Quarry Sites				Surveys were not made at quarry sites.
Opposite Massena Pt.				
S-184	0-5.6	1,420		The data are satisfactory. Bedrock is deeply buried.
	5.6-94.8	7,020		
	Rock	15,600		
Massena Springs				
S-419	0-5.0	1,250		The data are satisfactory. Bedrock is deeply buried.
	5.0-85.0	4,820		
	Rock	17,500		
Plum Brook				
S-423	0-5.6	1,600		The data is satisfactory. Bedrock is deeply buried.
	5.6-48.5	5,000		
	Rock	18,800		
Knapp's Station				
S-424	0-7.0	2,500		All data are satisfactory. Depth of bedrock is apparently quite variable and is some areas very shallow.
	Rock	5,500		
S-425	0-4.3	1,540		
	4.3-33.4	6,000		
	Rock	20,000		
S-426	0-4.8	1,820		
	4.8-23.8	7,300		
	Rock	20,000		
S-427	0-5.8	2,000		
	5.8-25.8	5,700		
	Rock	20,000		
S-428	0-8.8	1,250		
	Rock	15,600		
S-429	0-5.0	2,000		
	5.0-15.5	5,700		
	Rock	20,000		
S-430	0-5.6	1,050		
	Rock	16,500		
S-431	0-14.4	2,720		
	Rock	20,000		
S-432	0-5.1	950		
	5.1-27.7	8,500		
	Rock	17,500		
S-433	0-8.2	2,900		
	8.2-36.2	6,900		
	Rock	16,300		
S-434	0-4.4	1,180		
	4.4-23.7	4,400		
	Rock	17,500		
S-435	0-5.2	1,110		
	5.2-24.4	6,000		
	Rock	20,000		
S-436	0-5.2	1,110		
	5.2-16.9	8,350		
	Rock	14,000		
S-437	0-7.7	1,670		
	Rock	12,500		
Hogansburg-				
S-438	Rock	> 30' deep		All data are satisfactory or fair except lines S-439 to S-443 inclusive, which were unsatisfactory or no data were obtained. The depth to bedrock is variable and may be quite shallow in two areas.
S-439	No data			
S-440	No data			
S-441	No data			
S-442	Data erratic			
S-443	Data erratic			
S-444	Rock	7' deep		
S-445	Rock	>35' deep		
S-446	Rock	>35' deep		
S-447	Rock	>35' deep		
S-448	Rock	26' deep		
Quarry Sites (Cont'd)				
Hogansburg (Cont'd)				
S-449	Rock	> 26' deep		
S-450	Rock	15' deep		
Bormans Quarry				
S-388				Experimental lines fired to determine velocity in shallow rock.
S-389				
S-390				
S-391				

Note: WS = Water surface
G = Ground surface
R = Rock surface
FR = Fractured rock

File No. S-A-2/41
Sheet 8 of 8

TABLE III
COMPARISON OF SEISMIC INTERPRETATION
WITH DRILLING RECORDS
ST. LAWRENCE RIVER PROJECT

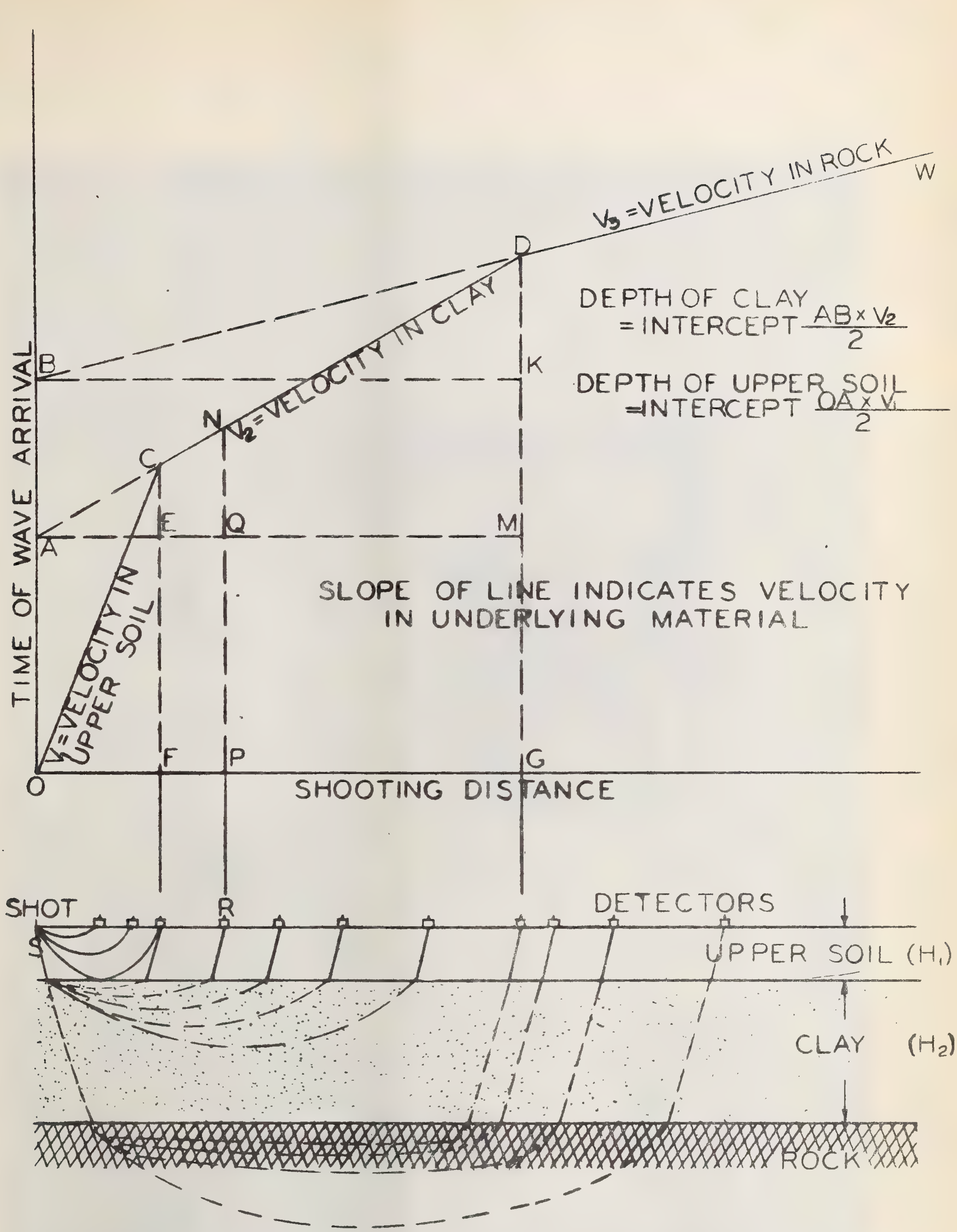
Seismic Line No.	Location	Drill Hole	Distance from Drill Hole to Seismic Center	Seismic			Drill Hole		
				Ground Elev.	Depth	Rock Elev.	Rock Elev.	Depth	Ground Elev.
S-2	Long Sault Dam	D 1019	20'	174.8	29.7	145.1	144.0	28.5	172.5
S-11	Long Sault Dam	D 1007	70'	212.7	56.6	156.1	160.1	53.0	213.1
S-12	Long Sault Dam	D 1007	120'	212.5	52.0	160.5	160.1	53.0	213.1
S-34	Power House	D 1029	57'	185.6	43.6	142.0	146.9	38.7	185.6
S-35	Power House	D 1136	90'	191.9	58.7	133.2	132.5	60.5	193.0
S-38	New Cornwall Canal	D 1121	140'	211.8	47.4	164.4	162.6	49.0	211.6
S-50	Iroquois Dam	D 1046	27'	231.5	25.0	206.5	206.4	25.9	232.3
S-66	Grass River Lock	D 1368	100'	184.0	74.3	109.7	104.4	77.5	181.9
S-68	Robinson Bay Lock	D 1070	126'	199.7	65.2	134.5	138.2	61.8	200.0
S-74	Ogden Island	D 1083	116'	232.1	53.0	179.1	183.5	50.6	234.1
S-88	Rockway Canal	D 1264	125'	228.5	26.8	201.7	202.1	24.8	226.9
S-89	Point Rockway Canal	D 1073	115'	229.5	30.0	199.5	198.1	34.2	232.3
S-158	Massena Canal Int. Wks.	D 1260	43'	218.4	41.6	176.8	171.3	47.3	218.6
S-164	Point Rockway Canal	D 1281	39'	228.0	21.1	206.9	200.5	27.0	227.5
S-175	Point Rockway Canal	D 1283	89'	241.1	9.0	232.1	233.8	4.1	237.9
S-203	Galop Island Channel	D 1110	0	247.7	41.3	206.4	205.4	42.3	247.7
S-207	Lalone Island Channel	D 1102	60'	236.5	15.0	221.5	221.8	26.0	247.8
S-225	Galop Island Channel	D 1109	173'	272.5	75.0	197.5	198.6	70.6	269.2
S-246	Galop Island Channel	D 1106	0	250.2	52.5	197.7	196.2	54.0	250.2
S-299	Iroquois Dam	D 1045	100'	233.5	31.6	201.9	208.1	23.5	231.6
S-318	Point Rockway Canal	D 1341	0	240.1	30.4	209.7	209.6	30.5	240.1
S-320	Point Rockway Canal	D 1379	0	237.1	4.5 (a) 14.6 (b)	232.6 222.5	232.6	5.0	237.6
S-323	Point Rockway Canal	D 1343	0	244.6	4.3 (a) 20.7 (b)	240.3 223.9	243.8	0.8	244.6
S-325	Point Rockway Canal	D 1378	40'	233.2	3.7 (a) 6.7 (b)	229.5 226.5	228.4	4.3	232.7
S-334	Iroquois Dam	D 1043	0	229.8	60.8	169.0	155.8	74.0	229.8
S-408	Long Sault Island	D 1391	150'	249.0	72.4	176.6	172.4	83.3	255.7
S-412	Long Sault Island	D 1390	0	257.5	77.5	180.0	168.9	88.6	257.5

(a) To top of fractured rock
(b) To top of sound rock

File No. S-A-2/45

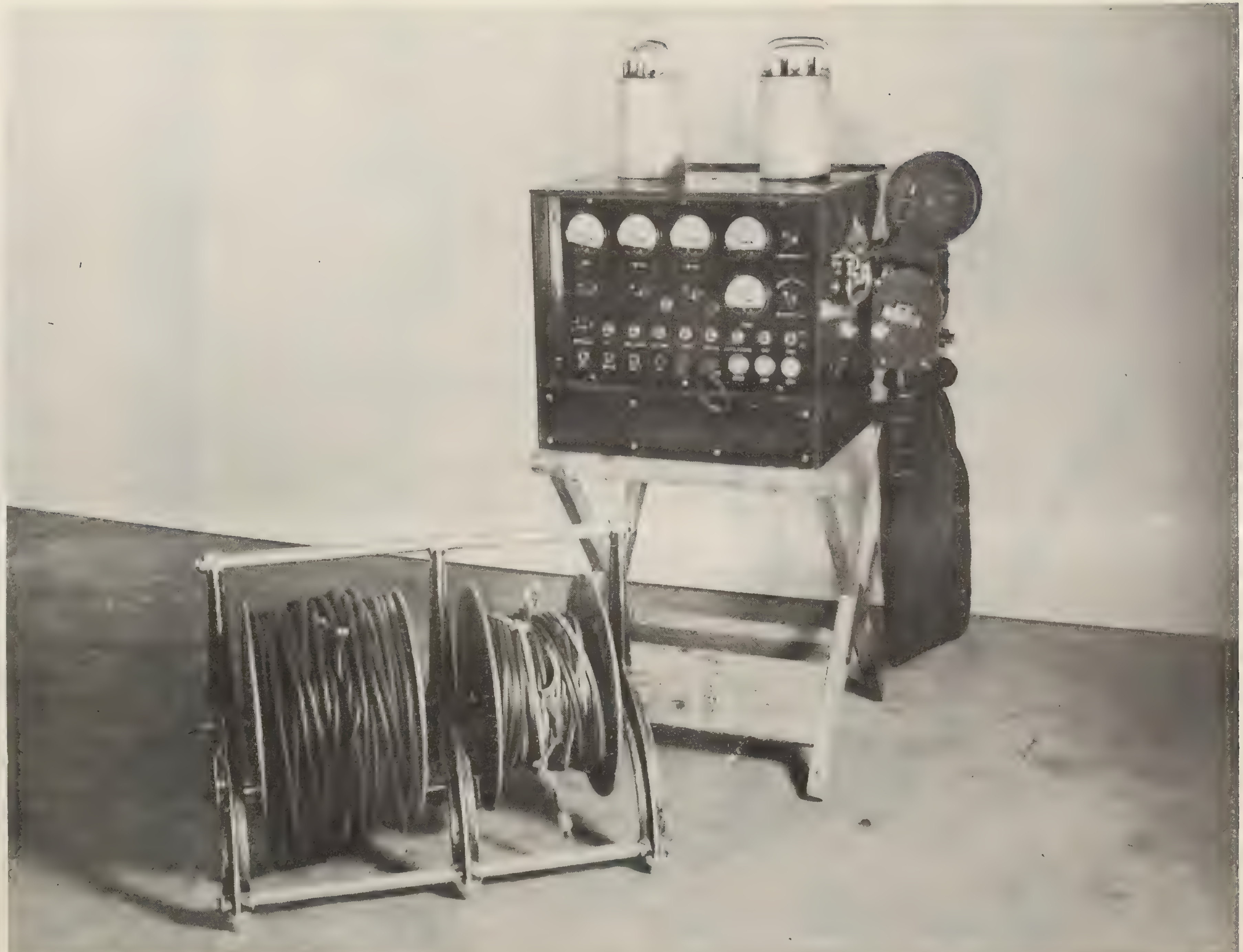
FILE NO. S-A-2/22

PLATE I



TIME-DISTANCE GRAPH FROM WHICH SOIL PROFILE DETERMINATIONS ARE MADE

FILE NO S-A-2/23
PLATE II



U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Portable Seismagraph

February 26, 1942

File No. 0-36
Plate III

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Seismic Method of Exploration
Detectors in Waterproof Casing
Pipe Mounting

June 20, 1941

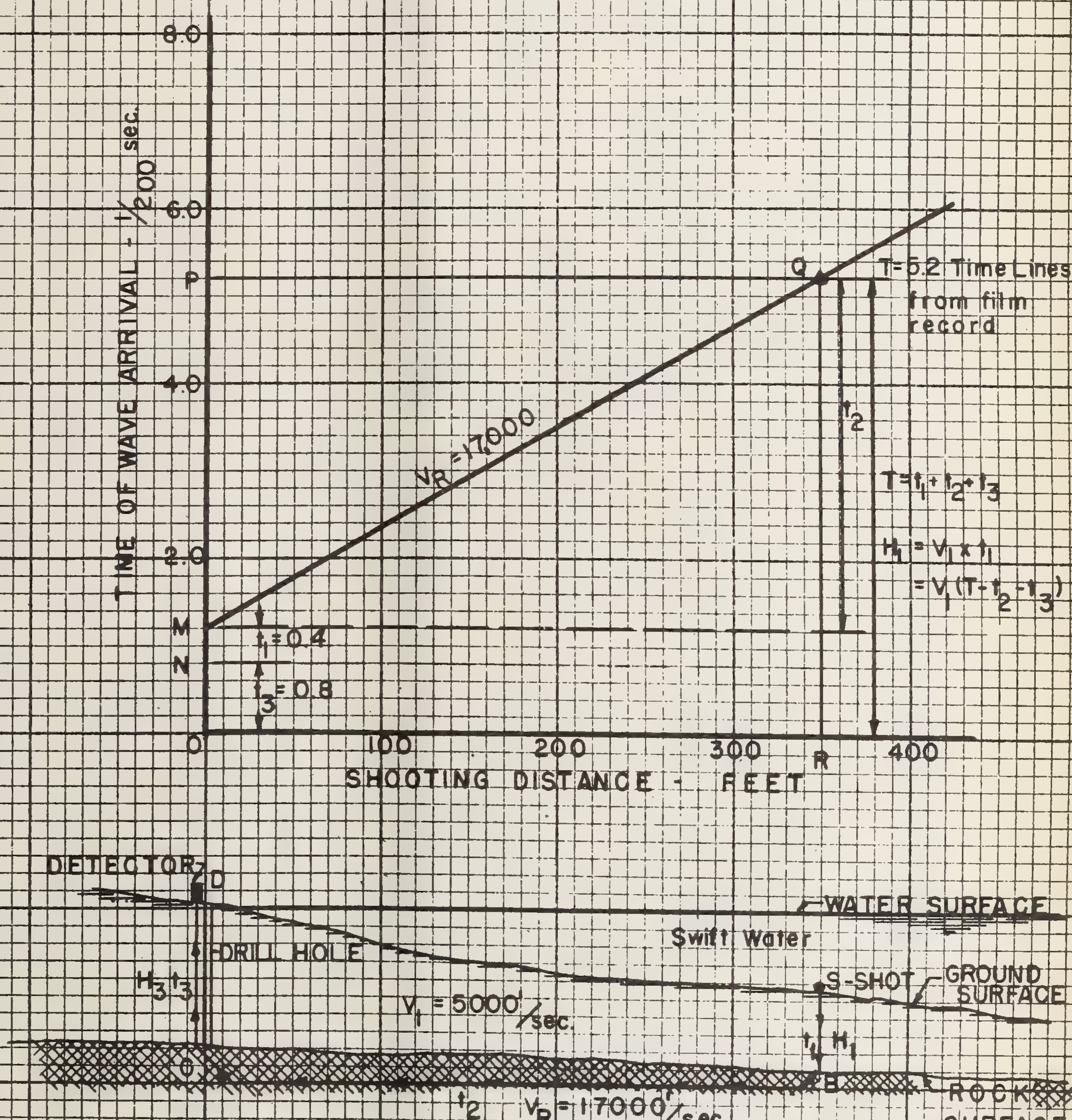
File No. 0-1
Plate IV

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

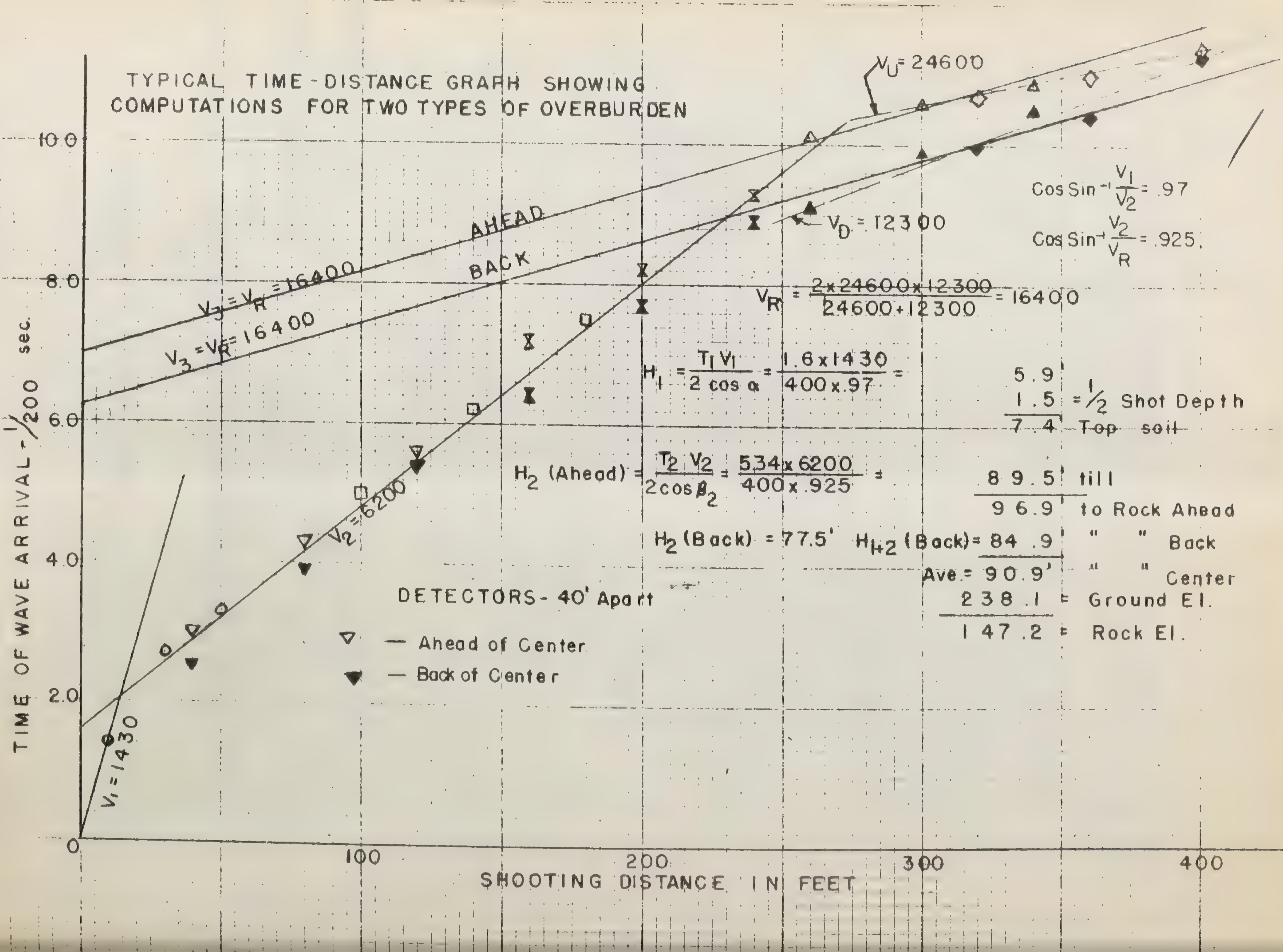
Seismic Method of Exploration
Triped & Detector Housing for use
in Deep Water

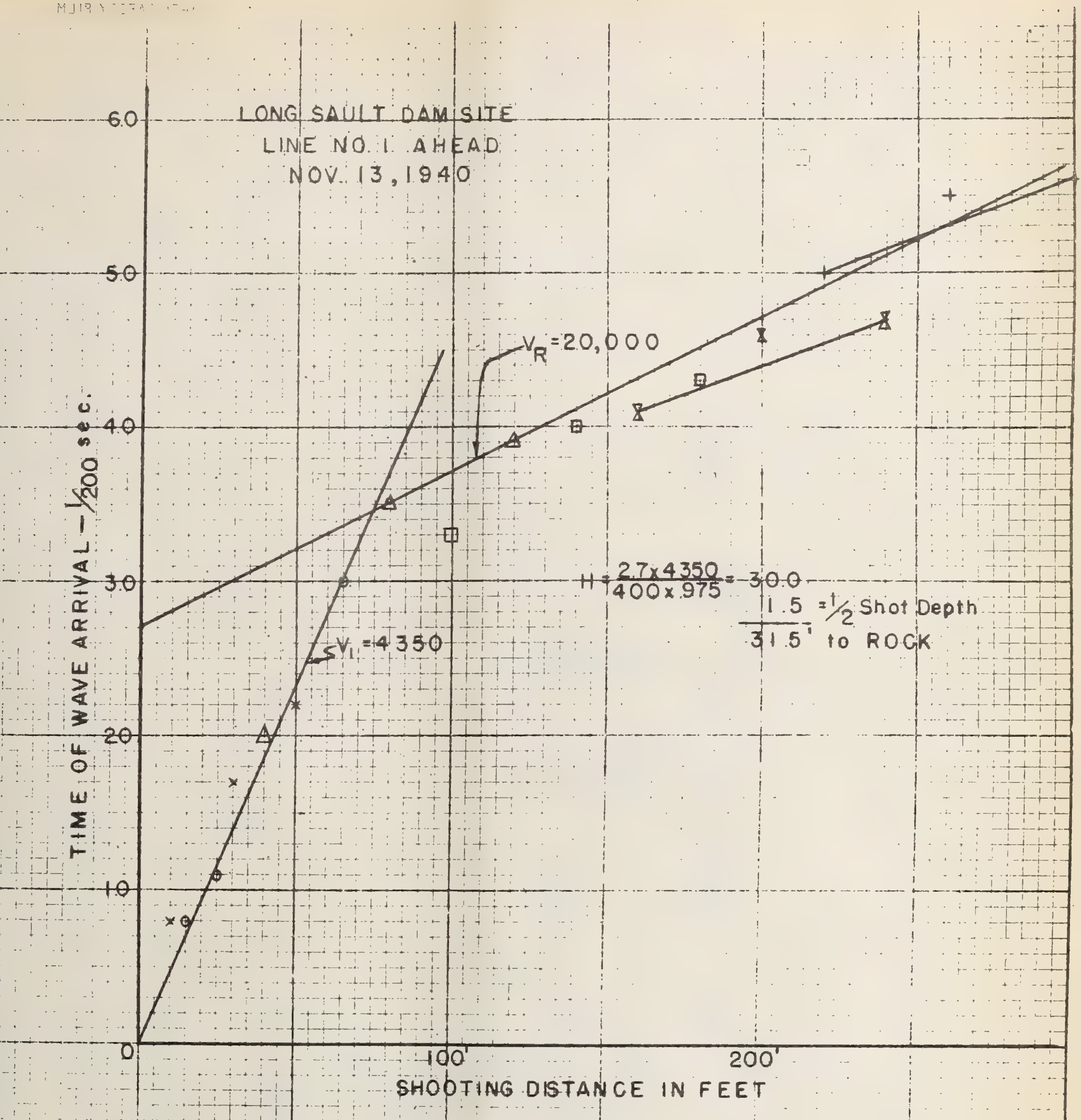
October 15, 1941

File No. 0-31
Plate V

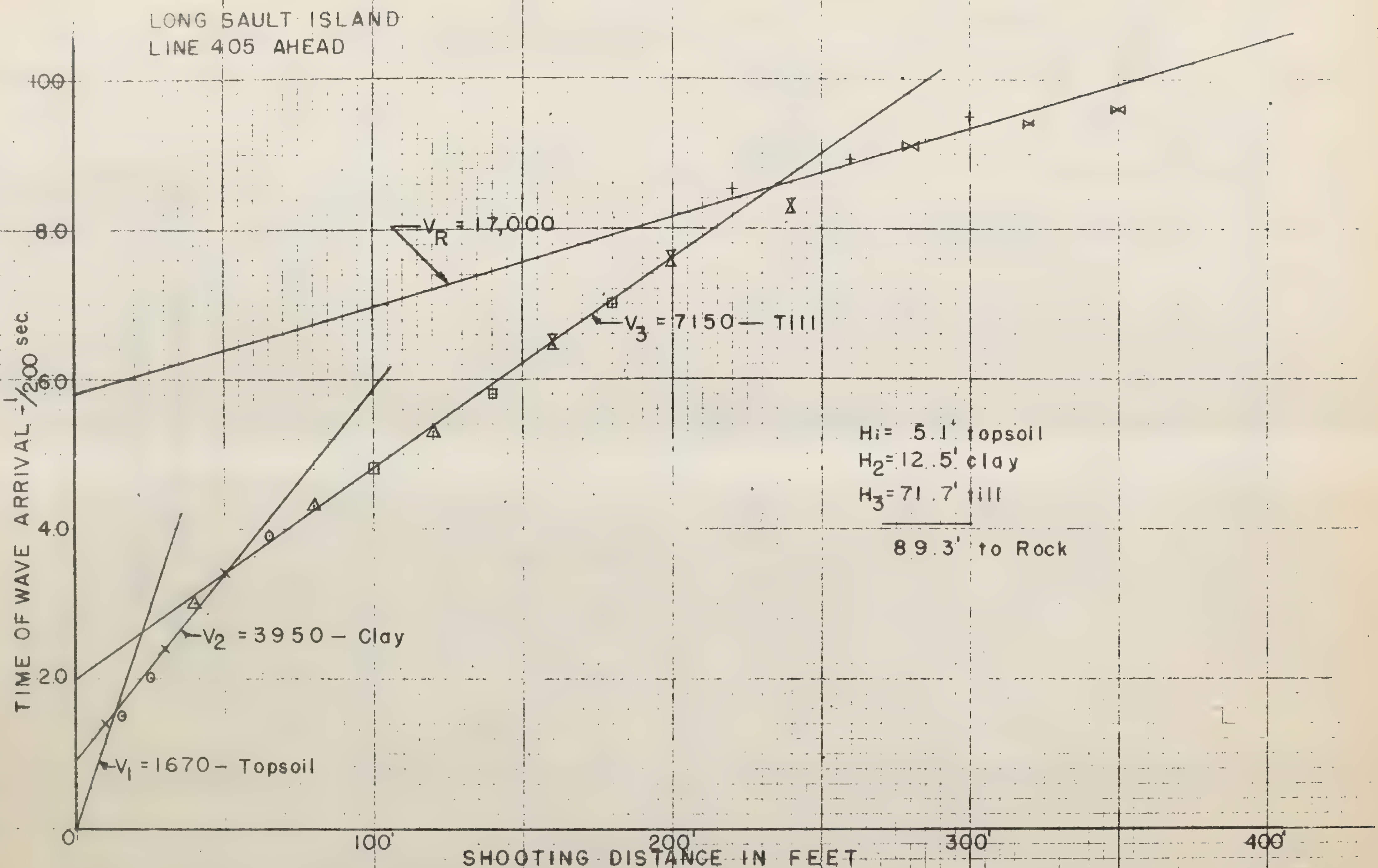


METHOD FOR DETERMINING DEPTH OF OVERBURDEN IN CHANNEL, LONG SAULT DAM SITE


TYPICAL TIME-DISTANCE GRAPH SHOWING
COMPUTATIONS FOR TWO TYPES OF OVERBURDEN
TIME OF WAVE ARRIVAL - 1/200 sec.
SHOOTING DISTANCE IN FEET
0
2.0
4.0
6.0
8.0
10.0
100
200
300
400
$V_U = 24600$
$V_D = 12300$
AHEAD
BACK
$V_3 = V_R = 16400$
$V_3 = V_R = 16400$
$V_2 = 6200$
$V_1 = 1430$
$\cos\sin^{-1}\frac{V_1}{V_2} = .97$
$\cos\sin^{-1}\frac{V_2}{V_R} = .925$
$V_R = \frac{2 \times 24600 \times 12300}{24600 + 12300} = 16400$
$H_1 = \frac{T_1 V_1}{2\cos\alpha} = \frac{1.6 \times 1430}{400 \times .97} =$
5.9'
1.5 = 1/2 Shot Depth
7.4' Top soil
$H_2 \text{ (Ahead)} = \frac{T_2 V_2}{2\cos\beta_2} = \frac{534 \times 6200}{400 \times .925} =$
89.5' till
96.9' to Rock Ahead
$H_2 \text{ (Back)} = 77.5'$
$H_{1+2} \text{ (Back)} = 84.9'$ " " Back
Ave = 90.9' " " Center
238.1 = Ground El.
147.2 = Rock El.
DETECTORS - 40' Apart
— Ahead of Center
— Back of Center

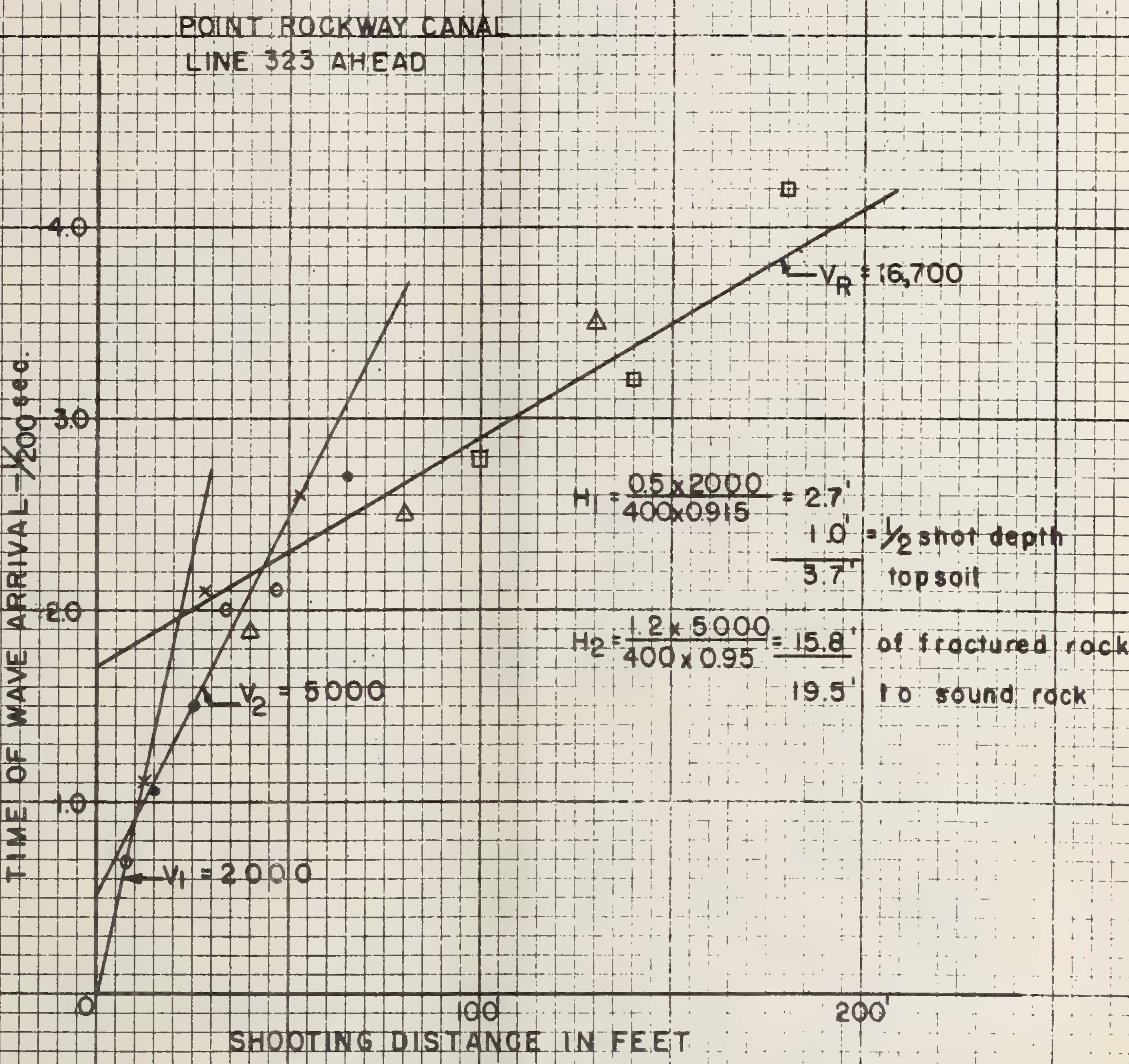


TYPICAL TIME-DISTANCE GRAPH SHOWING
SINGLE TYPE OF OVERBURDEN



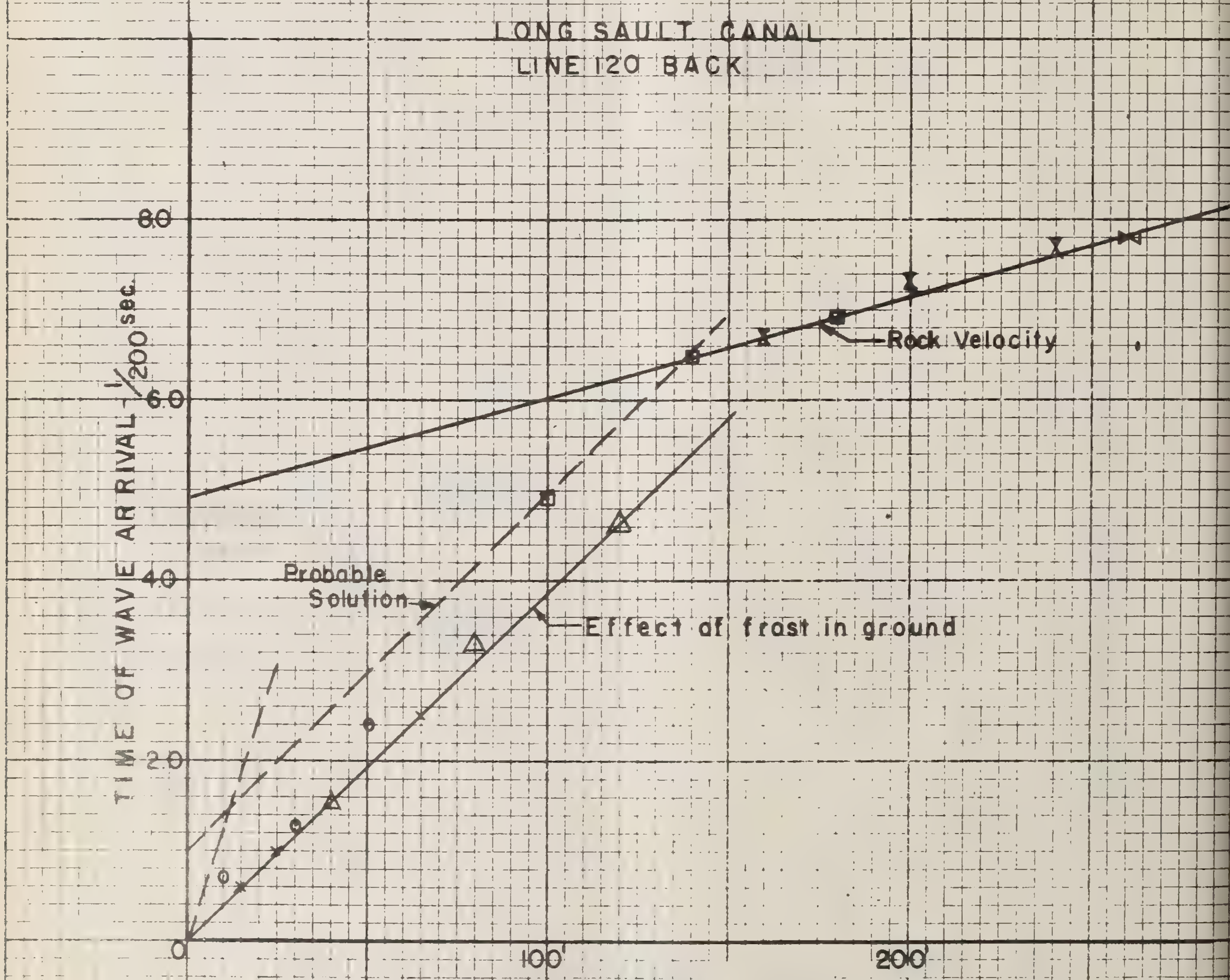
TYPICAL TIME·DISTANCE GRAPH SHOWING THREE TYPES OF OVERBURDEN

FILE NO. S-A-2/27 PLATE IX



TYPICAL TIME-DISTANCE GRAPH SHOWING SHALLOW ROCK

FILE NO. S-A-2/28 PLATE X



TYPICAL TIME-DISTANCE GRAPH SHOWING EFFECT OF FROZEN GROUND

FILE NO. S-A-2/29

PLATE XI

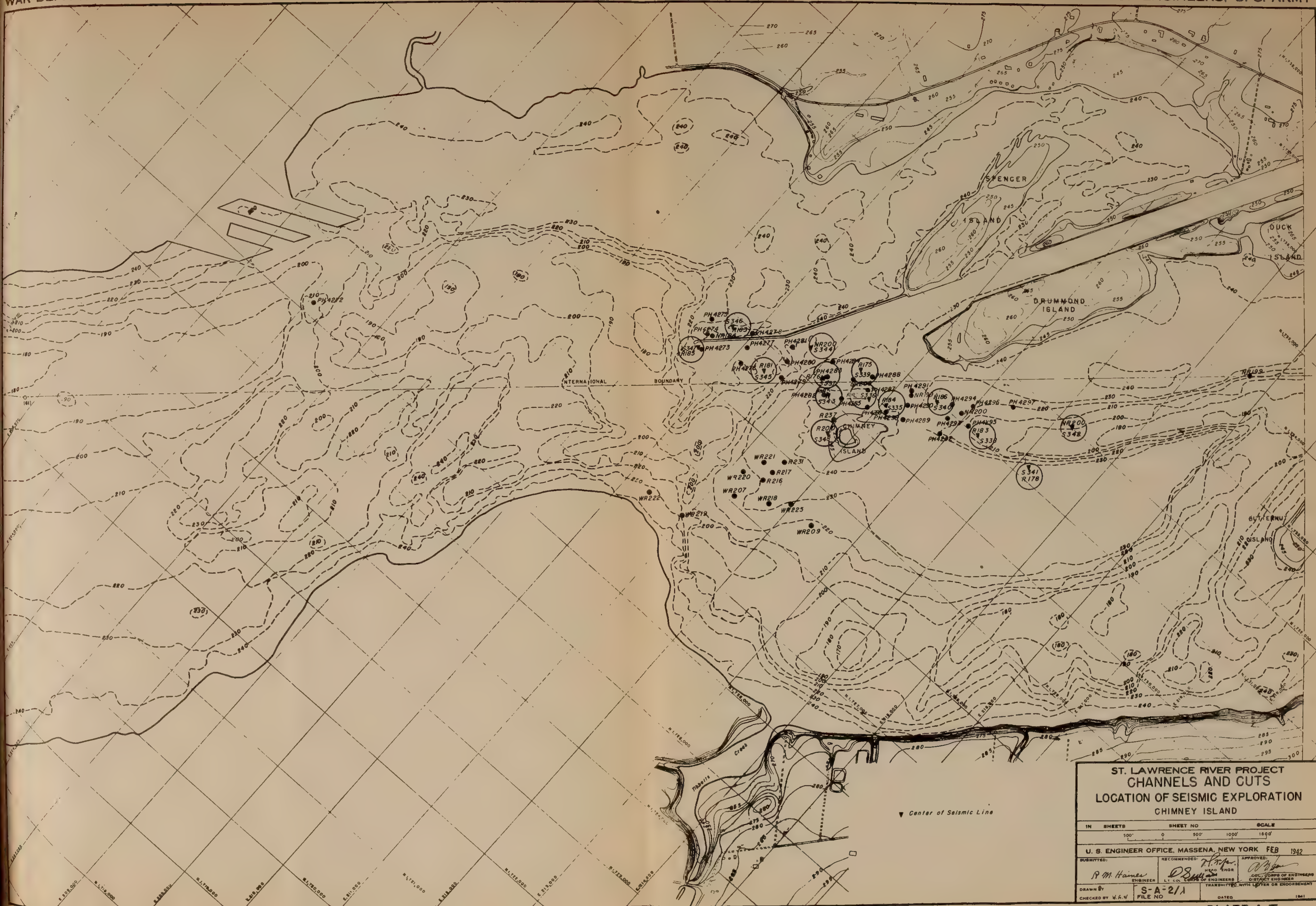

ST. LAWRENCE RIVER PROJECT
CHANNELS AND CUTS
LOCATION OF SEISMIC EXPLORATION
CHIMNEY ISLAND
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942
S-A-2/1
Center of Seismic Line
INTERNATIONAL BOUNDARY
SPENCER ISLAND
DRUMMOND ISLAND
DUCK ISLAND
CHIMNEY ISLAND
BUTTERNUT ISLAND

PLATE A-I

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

PLATE A-II

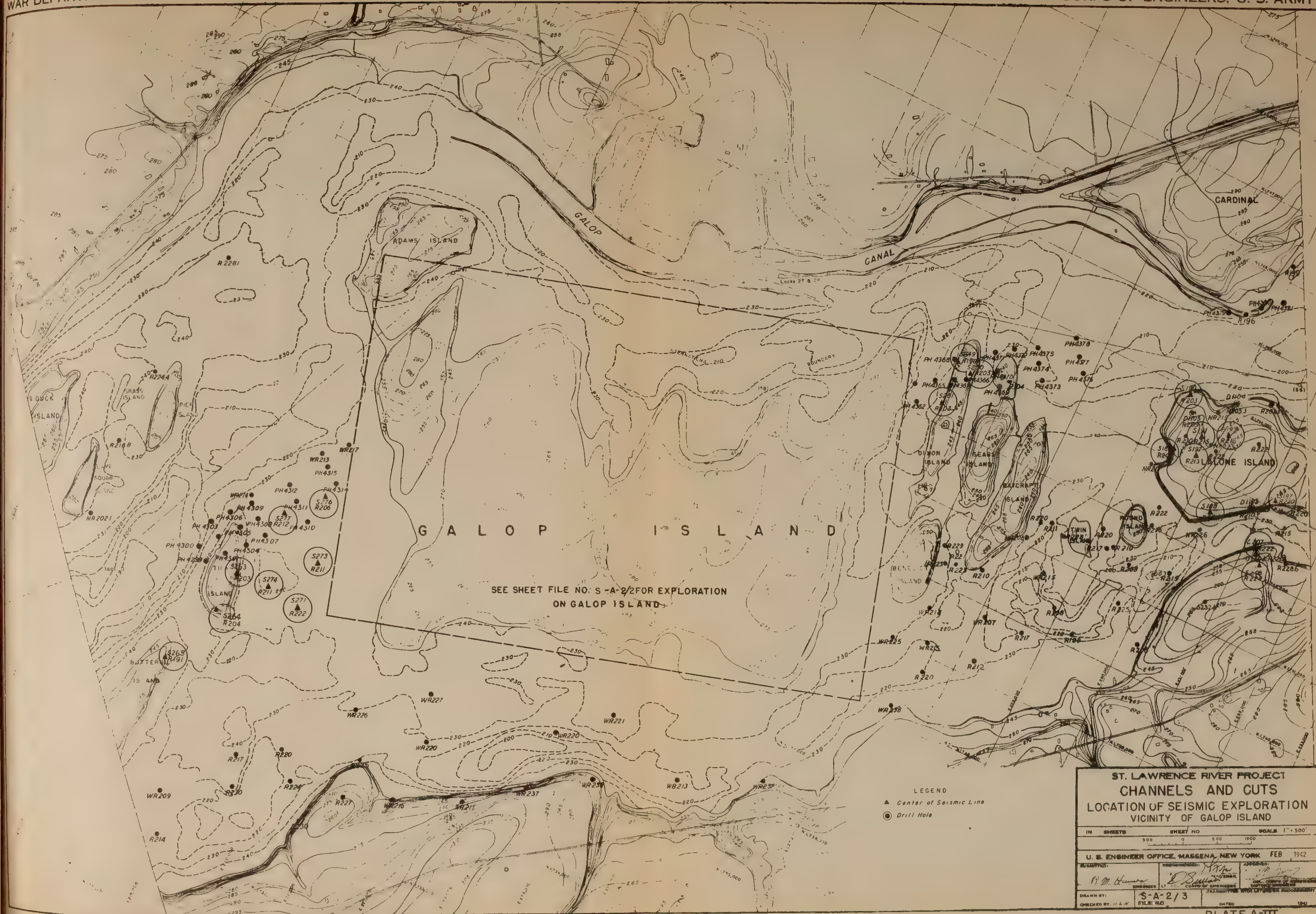

GALOP CANAL
CARDINAL
ADAMS ISLAND
GALOP ISLAND
SEE SHEET FILE NO. S-A-2/2 FOR EXPLORATION ON GALOP ISLAND
GALOP
CANAL
DIXON ISLAND
SEARS ISLAND
BANCROFT ISLAND
TWIN ISLAND
LALONE ISLAND
BENEDICT ISLAND
GRASS ISLAND
PIER ISLAND
DUCK ISLAND
SQUAW ISLAND
BUTTER ISLAND
LEGEND
▲ Center of Seismic Line
◉ Drill Hole
ST. LAWRENCE RIVER PROJECT
CHANNELS AND CUTS
LOCATION OF SEISMIC EXPLORATION
VICINITY OF GALOP ISLAND
SHEET NO
SCALE 1" = 500'
500 0 500 1000
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942
ENGINEER
LT. COL. CORPS OF ENGINEERS
S-A-2/3
FILE NO.
DATED
1941

PLATE A-III

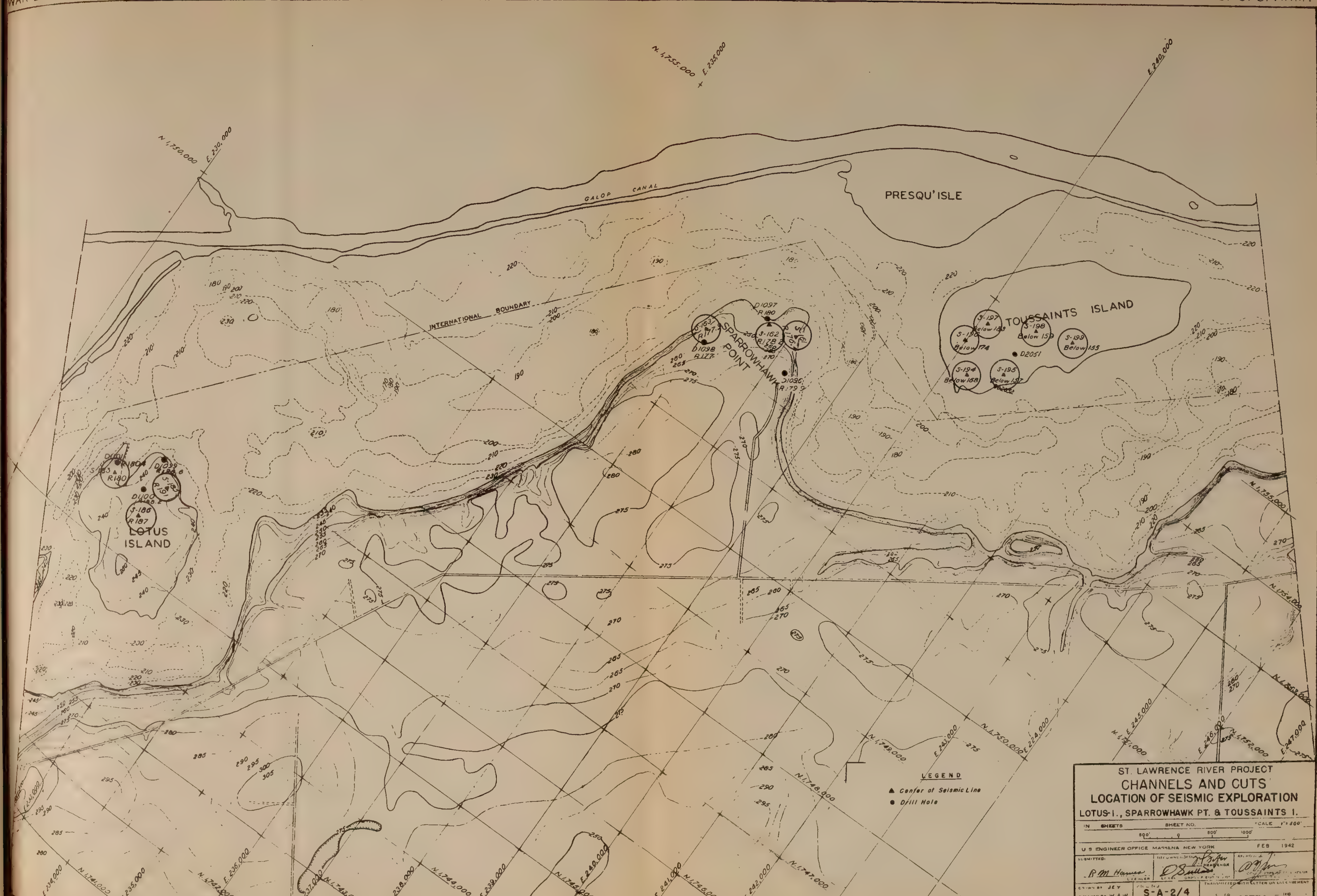

PRESQU'ISLE
GALOP CANAL
INTERNATIONAL BOUNDARY
TOUSSAINTS ISLAND
SPARROWHAWK POINT
LOTUS ISLAND
LEGEND
Center of Seismic Line
Drill Hole
ST. LAWRENCE RIVER PROJECT
CHANNELS AND CUTS
LOCATION OF SEISMIC EXPLORATION
LOTUS I., SPARROWHAWK PT. & TOUSSAINTS I.
U S ENGINEER OFFICE MASSENA NEW YORK
FEB 1942
S-A-2/4

PLATE A-IV

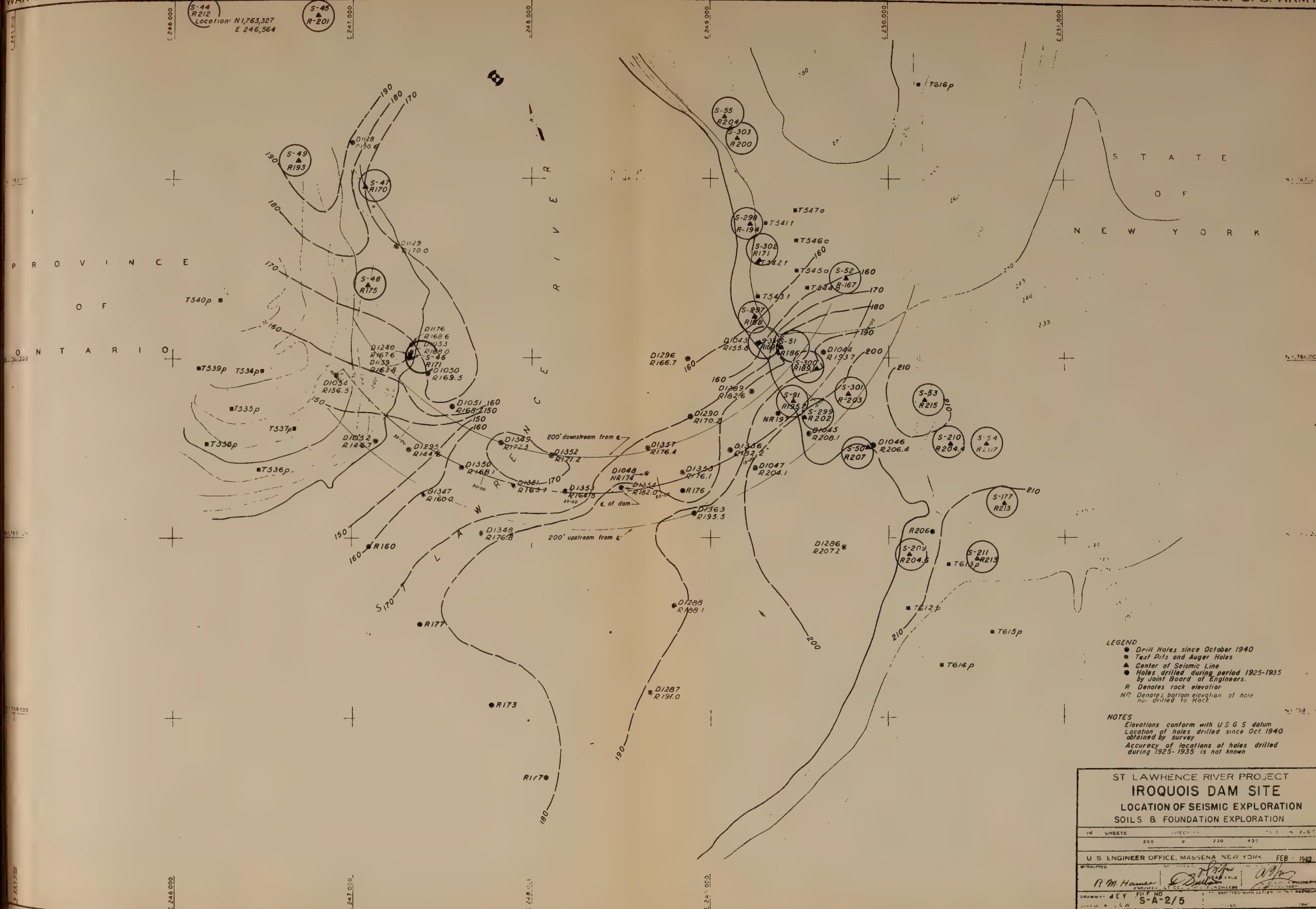
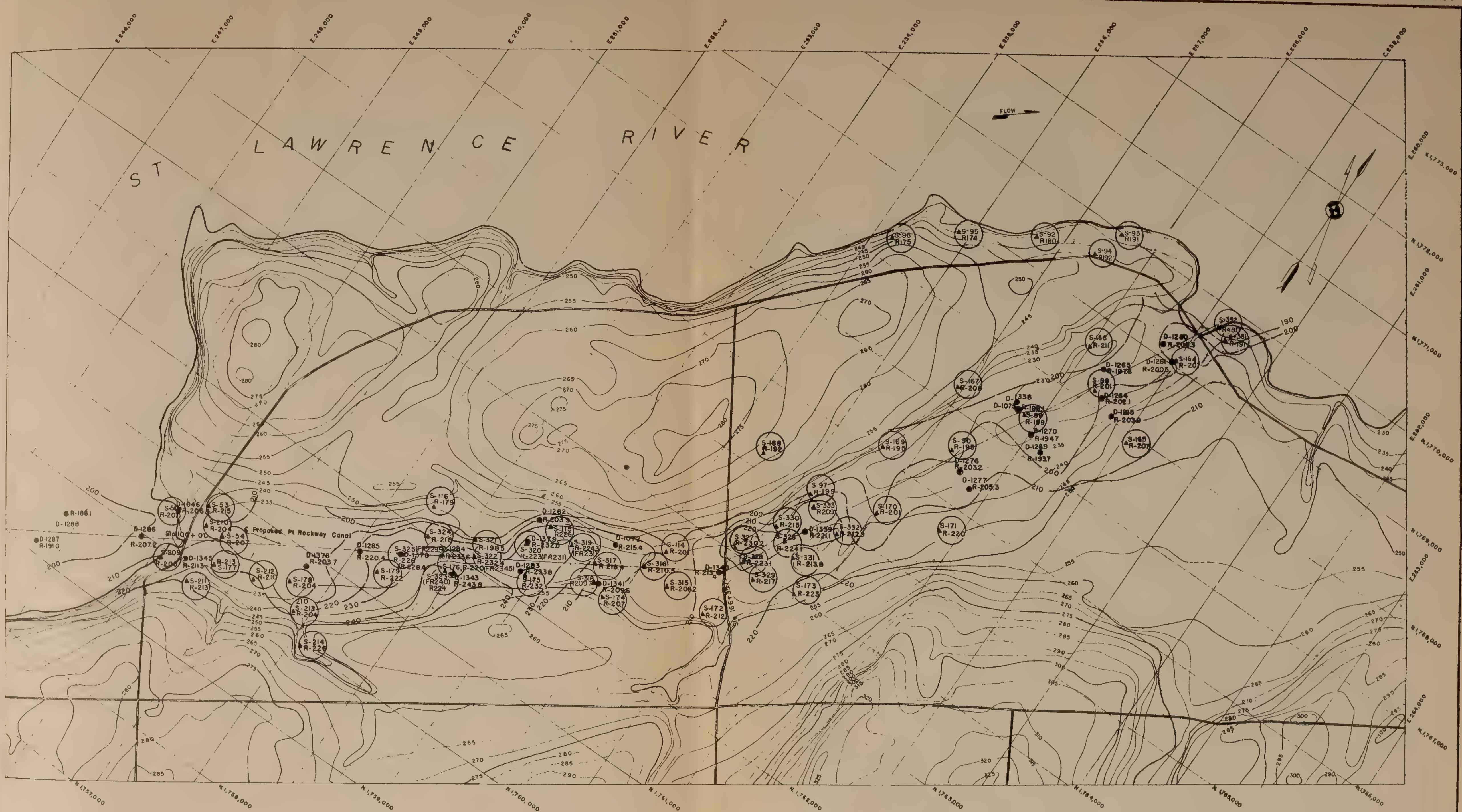

PROVINCE OF ONTARIO
STATE OF NEW YORK
ST LAWRENCE RIVER
200' downstream from ℄
℄ of dam
200' upstream from ℄
LEGEND
● Drill Holes since October 1940
■ Test Pits and Auger Holes
▲ Center of Seismic Line
● Holes drilled during period 1925-1935 by Joint Board of Engineers.
R Denotes rock elevation
NR Denotes bottom elevation of hole not drilled to Rock
NOTES
Elevations conform with U S G S datum
Location of holes drilled since Oct. 1940 obtained by survey
Accuracy of locations of holes drilled during 1925-1935 is not known
ST LAWRENCE RIVER PROJECT
IROQUOIS DAM SITE
LOCATION OF SEISMIC EXPLORATION
SOILS & FOUNDATION EXPLORATION
U S ENGINEER OFFICE, MASSENA NEW YORK FEB 1942
S-A-2/5

PLATE A-V

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



LEGEND

◉ DRILL HOLE
▲ CENTER OF SEISMIC LINE
R DENOTES ROCK ELEVATION

NOTES:

ELEVATIONS CONFORM WITH U.S.G.S. DATUM.
Due to the overburden and bedrock conditions in this area, the interpretation of the data is uncertain. Figures in parentheses are the probable surface elevation of slightly fractured and weathered bedrock. Figures not in parentheses are the probable elevations of sound bedrock.

ST. LAWRENCE RIVER PROJECT
POINT ROCKWAY CANAL
LOCATION OF SEISMIC EXPLORATION
SOILS & FOUNDATIONS EXPLORATION

IN SHEETS SHEET NO. SCALE 1" = 500

500' 0 500' 1000'

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942

SUBMITTED:	RECOMMENDED:	APPROVED:
R. M. Hames ENGINEER	HEAD ENGR. LT COL CORPS OF ENGINEERS	COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY:
CHECKED BY: H.A.M.
S-A-2/6
FILE NO.
TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED 1941

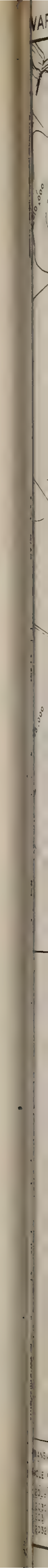
PLATE A-VI

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

PLATE A-VII


MORRISBURG
Morrisburg Canal
Lock 23
CANADA ISLAND
DORAN POINT
DORAN ISLAND
INTERNATIONAL BOUNDARY
OGDEN ISLAND
CLARK ISLAND
DRY ISLAND
MURPHY ISLAND
LEGEND
Center of Seismic Line
Drill Hole
ST. LAWRENCE RIVER PROJECT
CHANNELS AND CUTS
LOCATION OF SEISMIC EXPLORATION
VICINITY OF PT. THREE PT. TO DORAN ISLAND
NO. 2
U S ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942
S-A-2/8
CHECKED BY W.A.W.



PLAN

RECORD OF FOUNDATION EXPLORATION

D 2029

Depth	Elevation	Material
0.0	El. 239.2	
1.5	237.7	Loose, brown, SAND.
11.5	227.7	Loose, greyish-brown, slightly silty, SAND.
17.0	222.2	Soft, grey, slightly sandy, SILT and CLAY
39.4	199.8	Soft, grey, variable, silty, CLAY.
46.5	192.7	Soft, grey, slightly sandy, slightly gravelly, silty, CLAY
47.5	191.7	Loose, grey, slightly clayey, slightly gravelly, silty, SAND. Occasional boulders
48.5	190.7	Soft, grey, slightly gravelly, slightly sandy, silty, CLAY. Occasional boulders
49.5	189.7	Loose, grey, slightly clayey, slightly gravelly, silty SAND. Occasional boulders
51.0	188.2	Soft, grey, slightly gravelly, slightly sandy, silty, CLAY. Occasional boulders.
60.0	179.2	Fairly compact, grey, slightly clayey, silty, SAND and GRAVEL Occasional boulders.

D 2030

Depth	Elevation	Material
0.0	El. 237.8	
19.0	218.8	Loose, greyish-brown, slightly silty, SAND
23.5	214.3	Loose, grey, slightly clayey, SILT and SAND
66.0	171.8	Soft, grey, silty CLAY

D 2031

Depth	Elevation	Material
0.0	El. 239.0	
7.5	231.5	Loose, brown, slightly silty, SAND Few roots
11.5	227.5	Apparently, loose, grey, uniform, SAND.
29.7	209.3	Very soft to soft, grey, slightly silty to silty CLAY
31.0	208.0	Soft, grey, slightly gravelly, slightly sandy, silty, CLAY.
35.0	204.0	Loose to fairly loose, grey, slightly gravelly, slightly clayey, silty SAND Occasional boulders.
36.2	202.8	
39.0	200.0	Loose, grey, silty, SAND. Few pebbles.
46.0	193.0	Fairly compact, grey, slightly gravelly, silty, SAND. Occasional boulders.
50.5	188.5	Compact, grey, silty, SAND. Few pebbles. Occasional boulders.
		Compact, grey, slightly clayey, silty SAND. Few pebbles.

D 2032

Depth	Elevation	Material
0.0	El. 235.9	
10.0	225.9	Loose, brown, slightly clayey, silty, SAND
20.5	215.4	Soft, grey, slightly silty, CLAY
25.5	210.4	Loose, grey, slightly clayey, silty, SAND Few pebbles.
40.0	195.9	Variable loose to compact, slightly clayey, slightly gravelly, silty, SAND. Occasional boulders.

LEGEND

◉ Denotes Drill Hole

▲ Center of Seismic Line

DESCRIPTIVE TERMS

Slightly silty etc. denotes approximately 1% to 20% by dry weight of silt etc

Silty etc. denotes approximately 20% to 40% by dry weight of silt etc

Silt and sand etc. denotes approximately 40% to 60% by weight of silt etc. except "and clay" denotes more than 30% by weight of clay.

NOTE:
Elevations are based on Mean Sea Level.

TRANSVERSE MERCATOR COORDINATES

HOLE NO	NORTH	EAST
2029	1,794,370	314,760
2030	1,793,560	315,300
2031	1,799,380	324,800
2032	1,799,300	325,960

ST. LAWRENCE RIVER PROJECT
BRADFORD PT. & LOUISVILLE DIKES
LOCATION OF SEISMIC EXPLORATION

IN SHEETS SHEET NO SCALE 1" = 200'

1000' 0 1000' 2000'

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942

SUBMITTED R. M. Haines ENGINEER | RECOMMENDED HEAD ENGR. LT. COL. CORPS OF ENGINEERS | APPROVED COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY ff CHECKED BY W.A.W. | S-A-2/9 FILE NO | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

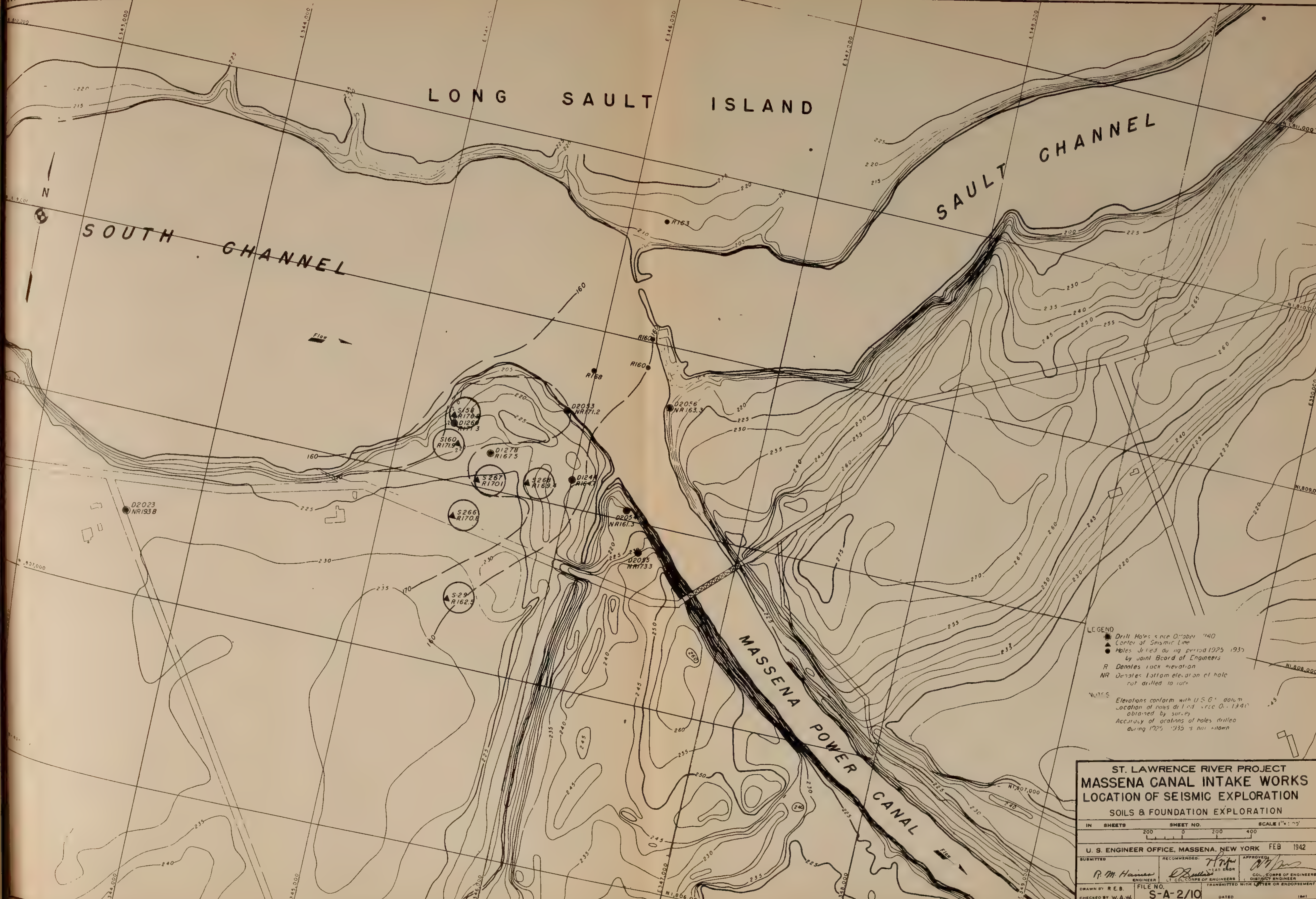

LONG SAULT ISLAND
SAULT CHANNEL
SOUTH CHANNEL
MASSENA POWER CANAL
N
LEGEND
Center of Seismic Line
by Joint Board of Engineers
R Denotes rock elevation
NR
NOTES
ST. LAWRENCE RIVER PROJECT
MASSENA CANAL INTAKE WORKS
LOCATION OF SEISMIC EXPLORATION
SOILS & FOUNDATION EXPLORATION
IN SHEETS
SHEET NO.
200 0 200 400
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942
SUBMITTED
R. M. Haines
ENGINEER
RECOMMENDED:
HEAD ENGR
LT. COL. CORPS OF ENGINEERS
APPROVED:
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DRAWN BY R.E.B.
CHECKED BY W.A.W.
FILE NO.
S-A-2/10
TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED

PLATE A-X


ST. LAWRENCE RIVER PROJECT
LONG SAULT DAM
LOCATION OF SEISMIC EXPLORATION
SOILS & FOUNDATIONS EXPLORATION
U S ENGINEER OFFICE MASSENA NEW YORK FEB 1942
FILE NO. S-A-2/11
LEGEND:
Drill Holes since Oct. 1940
Holes drilled prior to Oct. 1940
Center of Seismic Line
Test Pits & Auger Holes
R Denotes Rock Elevation
NR Denotes bottom elevation of Hole not drilled to Rock
NOTE:
Elevations conform to U.S.G.S. datum
Location of holes drilled since Oct. 1940 obtained by survey
Accuracy of location of holes drilled prior to Oct 1940 not known.
SS denotes seismic determination by single shot instead of line.
ONTARIO
CORNWALL CANAL
LONG SAULT ISLAND MAIN CHANNEL
INTERNATIONAL BOUNDARY
SHEEK ISLAND
BARNHART NORTH CHANNEL
BARNHART ISLAND
BARNHART ISLAND MAIN CHANNEL
LONG SAULT ISLAND
SOUTH CHANNEL
KEZAR BAY
PIKE HOLE
POLLY'S BAY
Borrow Areas
Borrow Area
NEW YORK STATE
LONG SAULT

PLATE A-XI

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

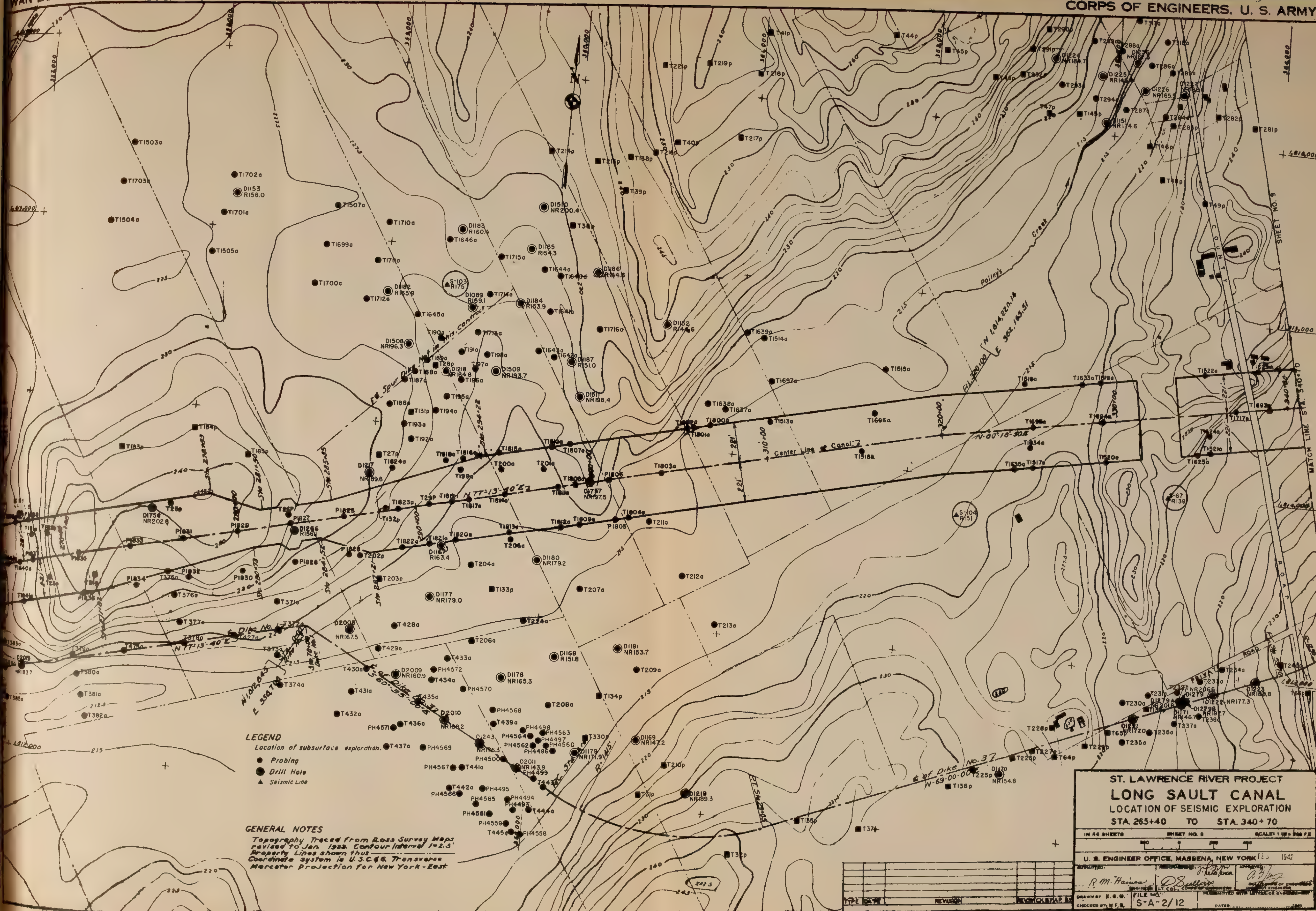


PLATE A-XII

WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
Center Line of Canal
Transmission Line
Steel Transmission Tower
3 Timber Poles
COUNTY ROAD
MATCH LINE FOR SHEET NO. 8
MATCH LINE FOR SHEET NO. 10
LEGEND
Location of subsurface exploration
Probing
Drill hole
Testpits
Seismic Line
GENERAL NOTES:
Topography traced from Ross Survey Maps revised to Jan. 1, 1923. Contour interval 2.5'
Property Lines shown thus
Coordinate system is the U.S.C.&G.S. Transverse Mercator Projection for New York, East.
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
LOCATION OF SEISMIC EXPLORATION
STA. 340+70 TO STA. 412+90
IN 44 SHEETS
SHEET NO. 9
SCALE 1IN=200FT
U.S. ENGINEER OFFICE, MASSENA, NEW YORK
FEB 1942
SUBMITTED
R. M. Haines
ENGINEER
RECOMMENDED
LT. COL. CORPS OF ENGINEERS
APPROVED
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DRAWN BY
CHECKED BY
FILE NO. S-A-2/13
TRANSMITTED WITH LETTER OR ENDORSEMENT
DATED
TYPE
DATE
REVISION

PLATE A-XIII

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

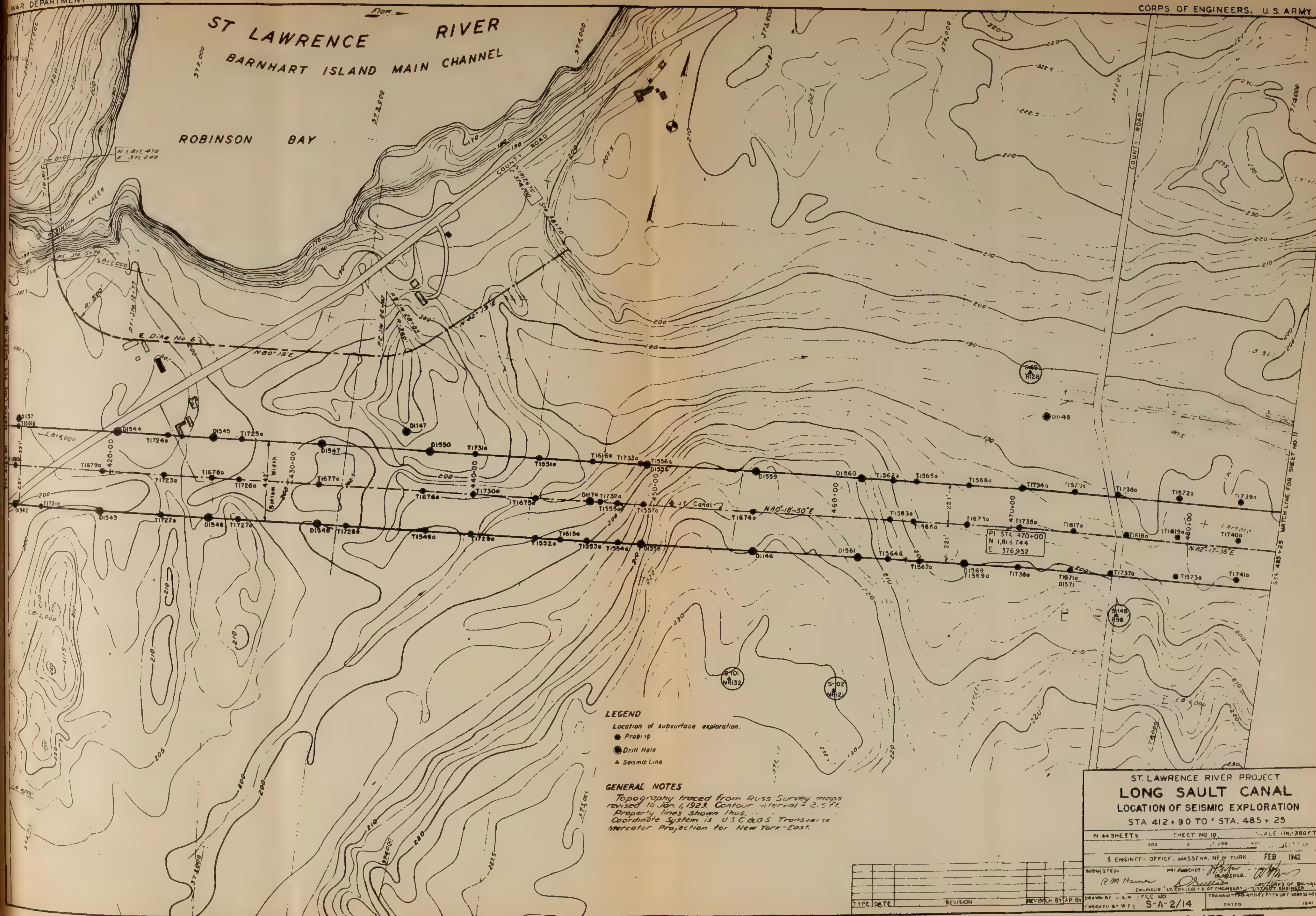


PLATE A-XIV

WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY

PLATE A-XV

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

PLATE A-XVI

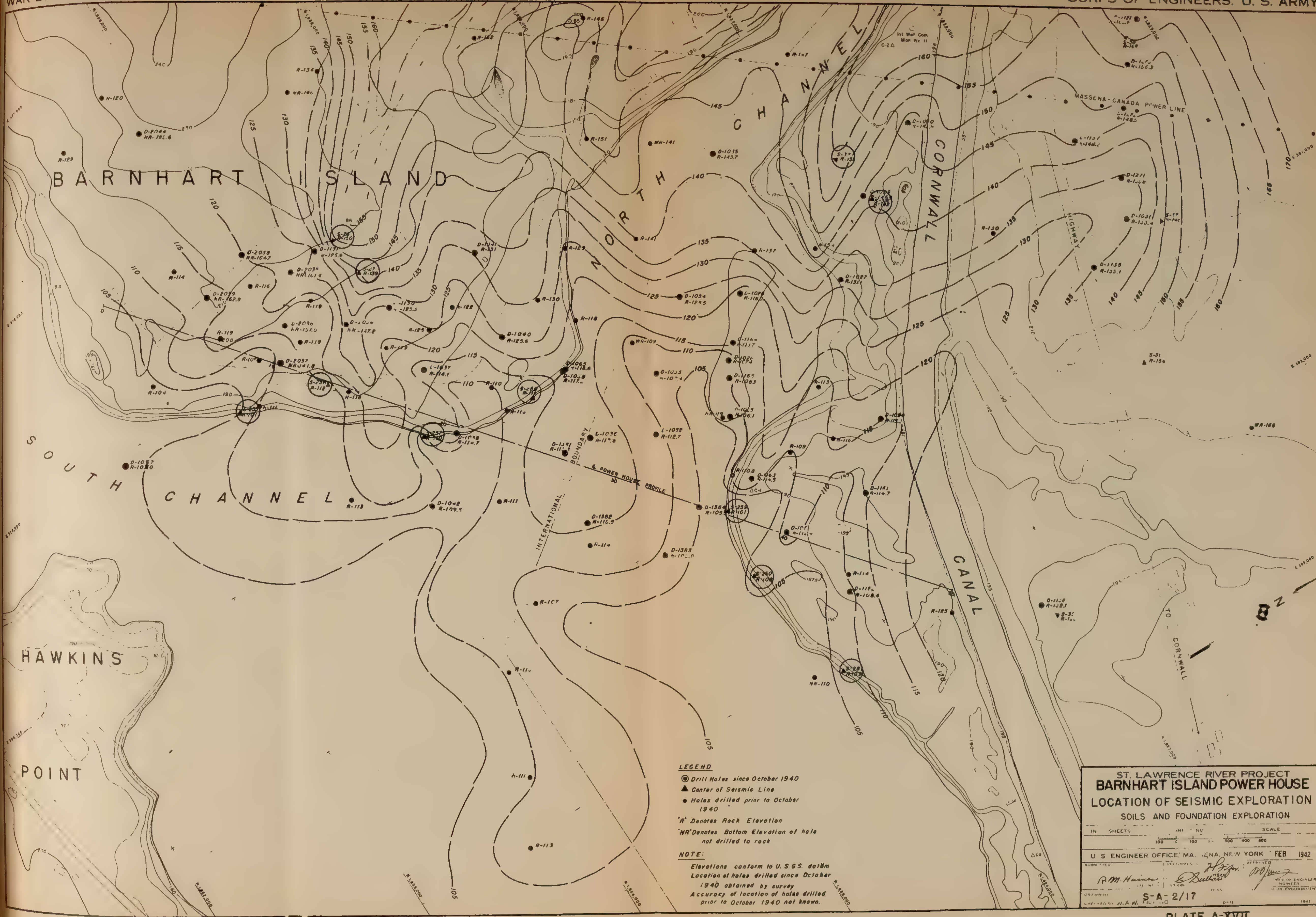

BARNHART ISLAND
NORTH CHANNEL
SOUTH CHANNEL
HAWKINS POINT
CORNWALL CANAL
HIGHWAY
TO CORNWALL
MASSENA-CANADA POWER LINE
INTERNATIONAL BOUNDARY
℄ POWER HOUSE PROFILE
LEGEND
Drill Holes since October 1940
Center of Seismic Line
Holes drilled prior to October 1940
"R" Denotes Rock Elevation
"NR" Denotes Bottom Elevation of hole not drilled to rock
NOTE:
Elevations conform to U. S. G. S. datum
Location of holes drilled since October 1940 obtained by survey
Accuracy of location of holes drilled prior to October 1940 not known.
ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER HOUSE
LOCATION OF SEISMIC EXPLORATION
SOILS AND FOUNDATION EXPLORATION
U S ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942
S-A-2/17

PLATE A-XVII

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

PLATE A-XVIII

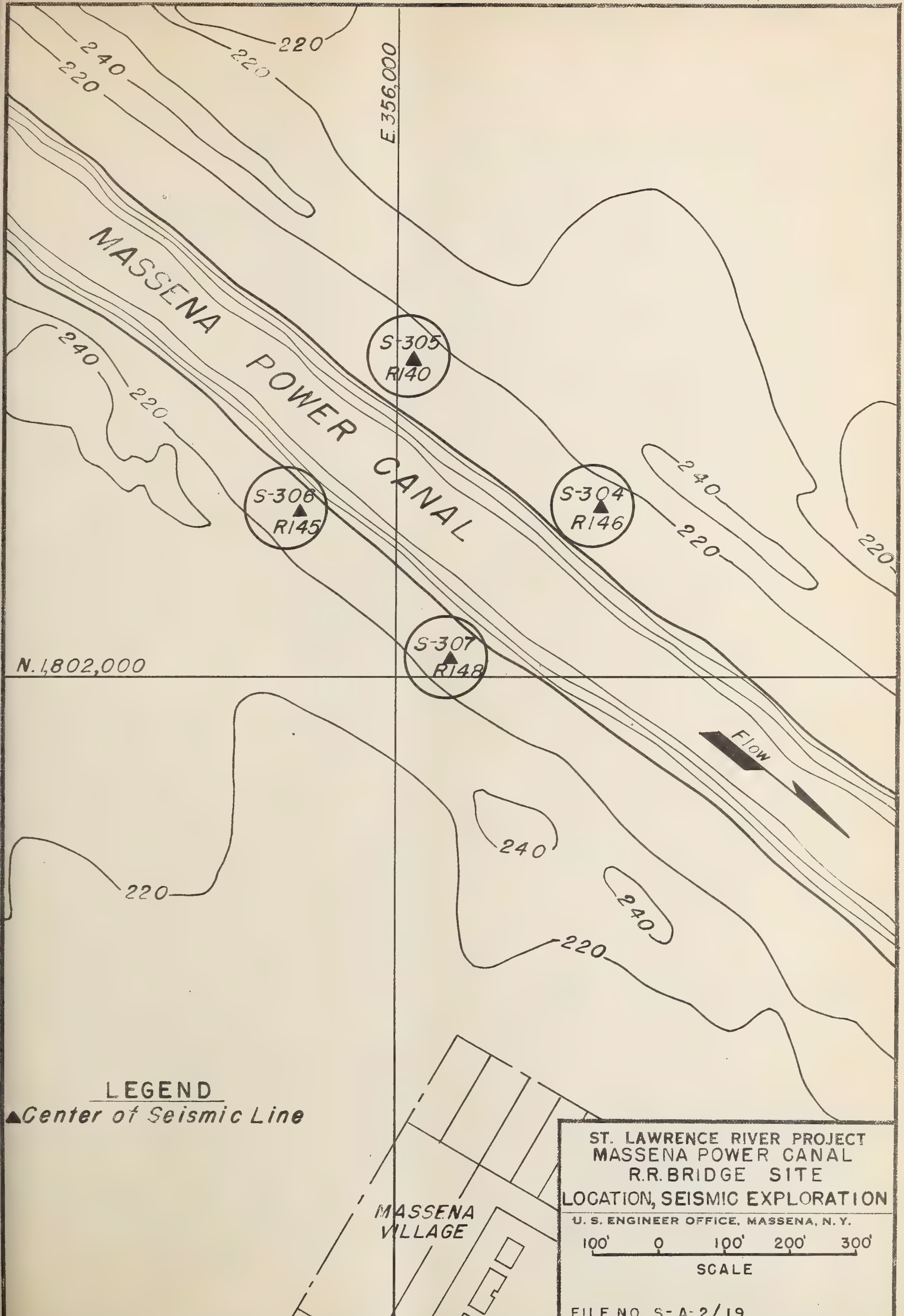
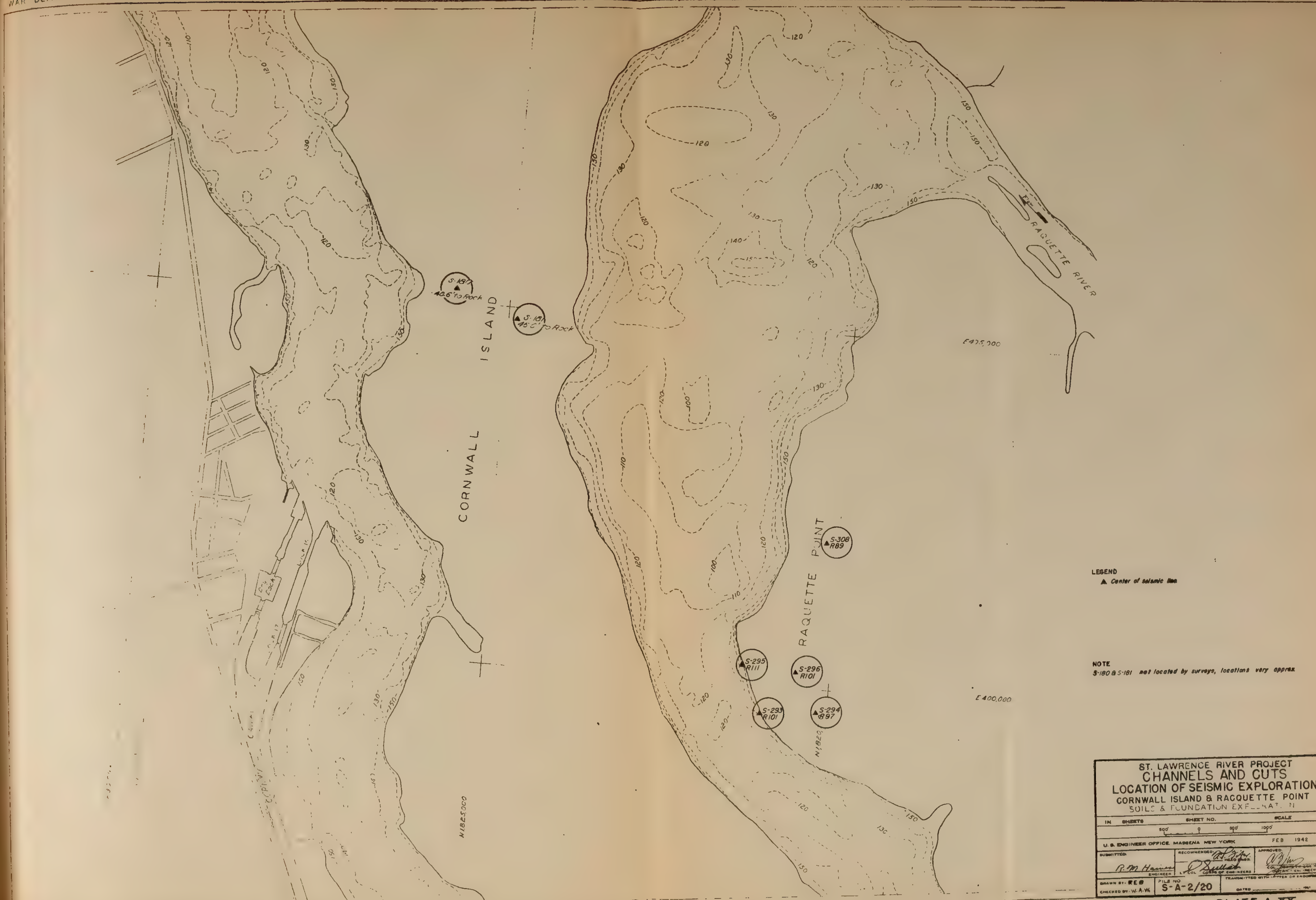

E.356,000
N.1,802,000
MASSENA POWER CANAL
S-305
R140
S-306
R145
S-304
R146
S-307
R148
Flow
240
220
MASSENA VILLAGE
LEGEND
▲Center of Seismic Line
ST. LAWRENCE RIVER PROJECT
MASSENA POWER CANAL
R.R.BRIDGE SITE
LOCATION, SEISMIC EXPLORATION
U. S. ENGINEER OFFICE, MASSENA, N. Y.
100' 0 100' 200' 300'
SCALE
FILE NO. S-A-2/19

PLATE A-XIX



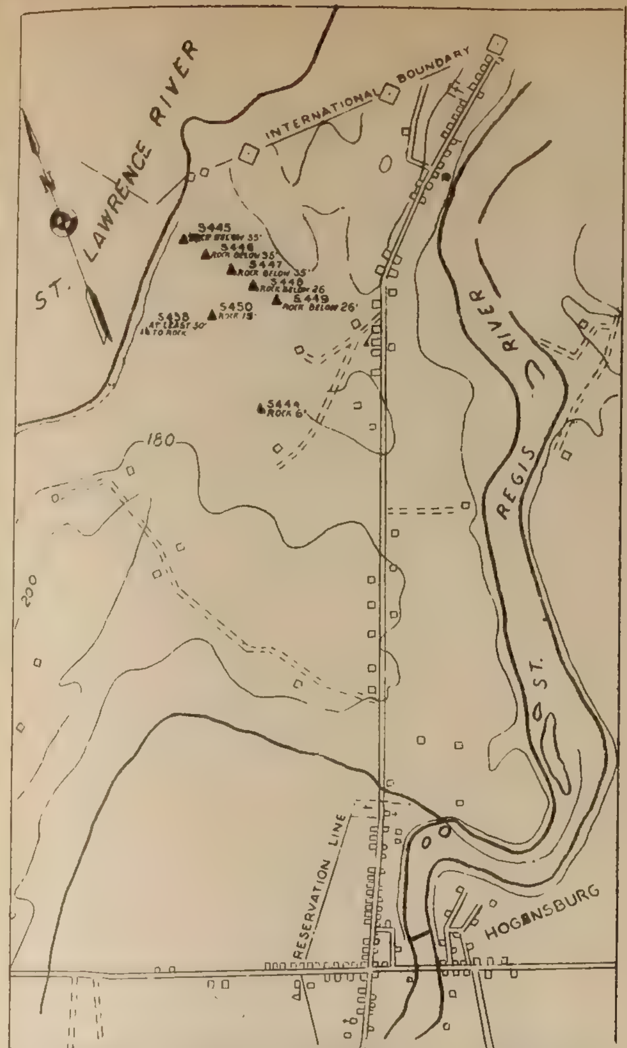
ST. LAWRENCE RIVER PROJECT
CHANNELS AND CUTS
LOCATION OF SEISMIC EXPLORATION
CORNWALL ISLAND & RACQUETTE POINT
SOILS & FOUNDATION EXPLORATION

IN SHEETS	SHEET NO.	SCALE 500' 0 500' 1000'
U. S. ENGINEER OFFICE, MASSENA NEW YORK		FEB 1942
SUBMITTED: R. M. Haines, ENGINEER	RECOMMENDED: HEAD ENGR. LT. COL. CORPS OF ENGINEERS	APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY: R.E.B. CHECKED BY: W.A.W.	FILE NO. S-A-2/20	TRANSMITTED WITH LETTER OF ENDORSEMENT DATED

PLATE A-XX

WAR DEPARTMENT

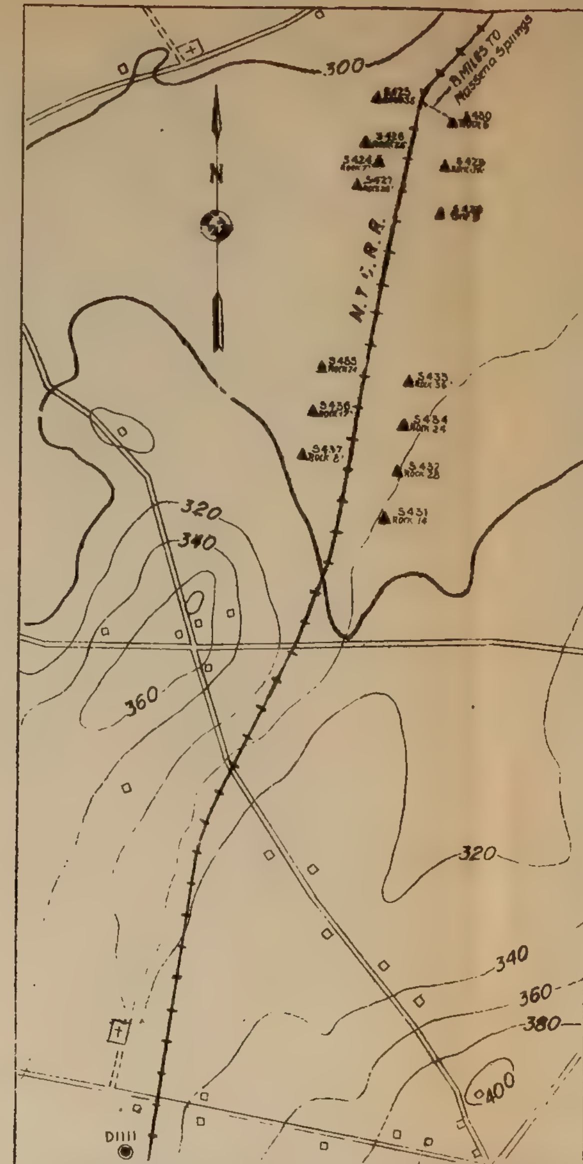
CORPS OF ENGINEERS U.S. ARMY



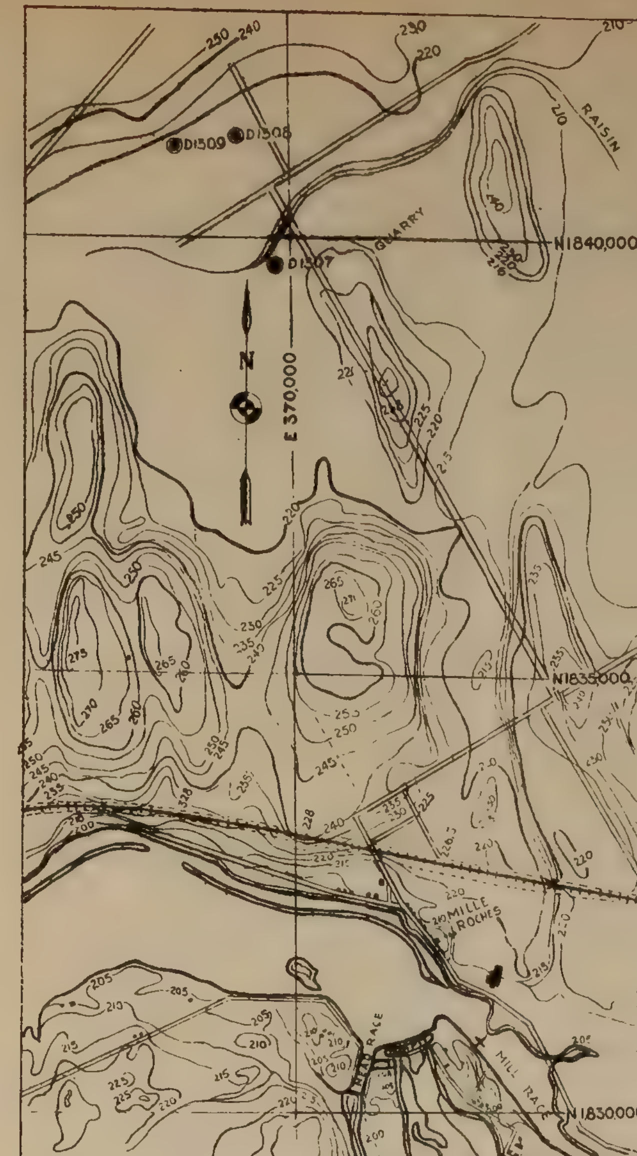
VICINITY OF HOGENSBURG Scale 1"-800'±

NOTE

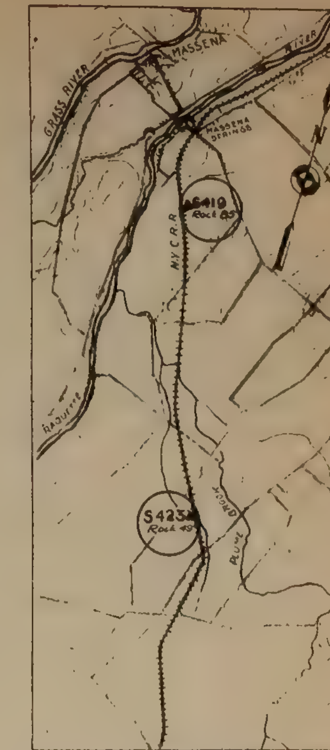
Shore of St. Lawrence River 7 miles from foot of Barnhart Island



VICINITY OF KNAPPS STATION 2MILES EAST OF E.NORFOLK N.Y. Scale 1"-800'±



VICINITY OF MILLE ROCHES QUARRY Scale 1"-1000'



VICINITY OF MASSENA SPRINGS & PLUM BROOK

NOTES

Maps obtained from U.S.G.S. and Canadian Topographical Maps

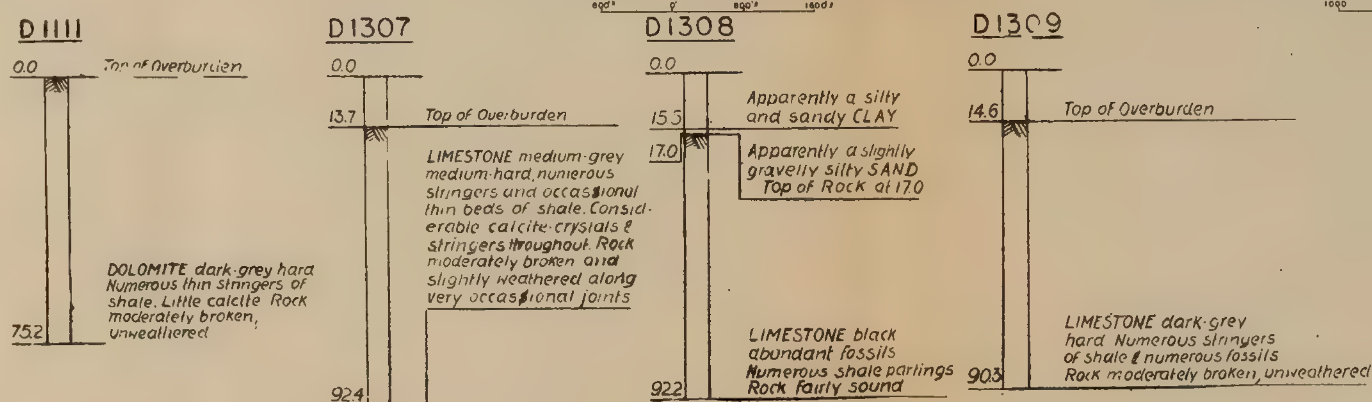
Location of Seismic and Drill-Holes are approximate

Analyses of bed-rock based on 2⅛" rock cores obtained by drilling

Legend.

◉ Drill Hole

▲ Center of Seismic Line



ST. LAWRENCE RIVER PROJECT

QUARRY SITE SURVEY

LOCATION OF SEISMIC EXPLORATION

SCALE AS SHOWN

U.S. ENGINEER OFFICE, MASSENA NEW YORK FEB 1942

SUBMITTED: R.M. Haines

RECOMMENDED: LT. COL. CORPS OF ENGINEERS

APPROVED: DISTRICT ENGINEER

CHECKED BY: W.A.W.

FILE NO. S-A-2/21

PLATE A-XXI

ST. LAWRENCE RIVER PROJECT

FINAL REPORT

DOCUMENTS Room

1942

CONCRETE & EMBANKMENT MATERIALS

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX C

ST. LAWRENCE RIVER

PROJECT

* * * * * *

FINAL REPORT

1942

CONCRETE & EMBANKMENT

MATERIALS

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office - Massena, New York

July , 1942

APPENDIX C

PART ONE - Concrete Aggregate Supply Specifications.

PART TWO - Concrete Aggregate Investigation.

PART THREE - Investigations of Sand and Gravel Sources for Roads, Filter and Backing Materials.

Appendix C

PART ONE

CONCRETE AGGREGATE SUPPLY SPECIFICATIONS

Invitation No. ________________

No.______Bidder____

____

(Do not write above this line)

STANDARD GOVERNMENT FORM INVITATION FOR BIDS
(SUPPLY CONTRACT)

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
MASSENA, NEW YORK

1. SEALED BIDS, in duplicate, subject to the conditions contained herein, will be received until 2:00 p.m. E.S.T.__________and then publicly opened in the United States Engineers Office, Massena, New York, for furnishing and delivering concrete aggregate as required for construction of the St. Lawrence River Seaway and Power Project.

2. SPECIFICATIONS

(a) All concrete aggregate furnished and the handling thereof shall be in strict accordance with the specifications.

3. INVESTIGATION OF CONDITIONS. - Bidders are expected to visit the localities and sites of the delivery points, and to make their own estimates of the difficulties attending the execution of the proposed contract, including local conditions, transportation facilities, availability of labor, uncertainty of weather, and other contingencies. In no case will the Government assume any responsibility whatever for any interpertation, deduction, or conclusion drawn in from such examinations. At the bidder's request, a representative of the Government will point out the approximate locality of the delivery points. Failure to acquaint himself with all available information concerning these conditions will not relieve the successful bidder of assuming all responsibilities for completing delivery to the required locations as explained in Section I of these specifications.

4. ARTICLES ON PATENTS will be made a part of the contract. (See paragraph 1-17 of the specifications.)

5. COMMENCEMENT AND COMPLETION.- Deliveries will be commenced within 90 calendar days after date of receipt of notice to proceed and shall be completed in accordance with the provisions of paragraph 1-04 of the specifications.

6. LIQUIDATED DAMAGES for delay will be prescribed. (See paragraph 1-04 of the specifications.)

7. PAYMENTS.- (See paragraph 1-05 of the specifications and Article 8 of the contract.)

8. ADJUSTMENT OF PRICES FOR LABOR AND MATERIAL.- Adjustment of prices in accordance with basic increase or decrease of costs of labor and material will be made as provided in paragraph 1-06 of the specifications.

9. TAXES.-

(a) Federal Taxes. - Title IV of the Revenue Act of 1932 (47 Stat. 169, 259), as amended by Section 4 of the Act of June 16, 1933 (48 Stat. 255), and Section 401 of the Act of August 30, 1935 (49 Stat. 1014, 1025), imposed Federal Taxes upon certain specified articles sold in the United States, to be paid by the manufacturer or producer, or imported into the United States, to be paid by the manufacturer, producer, or importer, but provided that no tax under this title shall be imposed with respect to the sale of any article for the exclusive use of the United States, and that a credit against the tax or a refund may be allowed or made with respect to the sale of any article if such article was resold for the exclusive use of the United States and the manufacturer, producer, or importer has such evidence as the regulations of the Commissioner of Internal Revenue may prescribe.

Bids will be evaluated on a Federal-Tax-Exclusive basis, except that when this is not practicable they will be evaluated on a Federal-Tax-Inclusive basis. Therefore, bids are requested exclusive of Federal taxes from which exemption is granted or as to which a credit or refund is provided for by title IV of the Revenue Act of 1932 as amended. If the bid prices are exclusive of such taxes, or are inclusive of such taxes and the bidder agrees to the deduction of the amount thereof from the contract price and acceptance of tax-exemption certificates in lieu thereof, the bidder must show upon the face of his bid the amount of each such tax so included or excluded as to each item, so that a tax exemption certificate can be furnished him if his bid is accepted. If the bid as submitted does not show that such taxes are excluded and the bidder does not agree to their deduction if included, it will be presumed that the amount of all such taxes is included in the bid price, the bid will be evaluated accordingly, and if the bid is accepted no exemption certificate will be issued. (See Article 21 of the contract).

(b) State Taxes. - To facilitate evaluation of bids no State or local taxes charged directly on the sale of goods should be included in bid prices, but whether or not included, the amount of such state taxes should be shown in detail so the appropriate computation may be made to determine the low bid and whether exemption certificates should be issued, etc. The evaluation of bids will be on a Tax-Exclusive basis since such State or local sales tax is not chargeable to the Federal Government and if the bid as submitted does not clearly show that any such tax is excluded or that the bidder consents to the deduction thereof in a stated amount or amounts, it will be presumed that the amount of the tax is included in the bid price, the bid will be evaluated accordingly, and if the bid is accepted no exemption certificate will be issued.

10. BID AND CONTRACT.

(a) Bids must be submitted upon the standard Government form of bid, (U.S. Standard Form No. 31), and the successful bidder will be required to execute War Department Supply Contract Form No. 1.

(b) The bid form has an entry for each item on which estimates will be given and payments made, and no other allowance of any kind will be made unless specifically provided for in the specifications or the contract, (See Article 3 of the contract.)

(c) Any bidder may bid on one or more of the schedules included in the attached Standard Government Form of Bid. To facilitate the possible combining of the concrete aggregate requirements for different construction jobs under this contract, appropriate schedules are provided for combination bidding.

11. DATA TO BE SUBMITTED WITH BIDS.

(a) All bids submitted must be accompanied by a statement establishing that the bidder maintains a permanent place of business and has a suitable financial status to meet obligations incident to the work. (See applicable paragraphs of the bidding schedule.) In addition, each bidder shall submit with his bid a statement of plant, drawings, charts, routing of shipments, specific gravity of materials, and other information required below. These data shall be carefully prepared and presented in neat and legible form on tracing paper or tracing cloth so that reproduction may be made therefrom. These data are considered essential in enabling the contracting officer to determine whether the bidder is responsible and experienced in similar enterprise and whether the bid is based on a careful study of methods applicable to the work and full realization of the various factors which may affect the progress of the work.

(b) After the bids are opened, any bidder may be required by the contracting officer to state whether he is now or ever has been engaged in furnishing aggregate similar to that proposed, the year in which it was done, and the manner of its execution, and to give such other information as will tend to show his ability to furnish the material required by these specifications.

(c) Sketches shall be submitted indicating each and every plant layout the bidder proposes to utilize in the production and processing of concrete aggregates. The sketches shall clearly show th location and manner of employment of the various major items of the plant and shall include the arrangement of the plant or plants for the handling of material, the location of all material yards, and the transportation facilities. The plant layout shall be accompanied by a complete list and description inserted in the space provided therefor in the bid form, of all plant that the bidder now has or will have available for commencing and prosecuting this work, and its location at the time of opening bids, in order that it may be inspected by the contacting officer should he so desire. The above information will be considered confidential. When a bidder does not own or possess plant and proposes to procure it, firm options on all major items of proposed plant must be submitted when the bids are opened.

12. AWARD OF CONTRACT.

(a) Subject to the rights hereinafter reserved, the furnishing of concrete aggregate will be awarded to the lowest responsible bidders whose proposals fully conform to the requirements of the specifications as may be deemed most advantageous to the United States.

(b) Award to one or more bidders will be made on the following basis:

(1) washed natural sand;
(2) crushed stone sand;
(3) washed gravel, sizes 3/16" to 3/4", 3/4" to 1-1/2", 1-1/2" to 3", and 3" to 6".
(4) crushed stone, sizes 3/16" to 3/4", 3/4" to 1-1/2", 1-1/2" to 3", and 3" to 6".

(c) In awarding the contract, aggregates of greatly different specific gravities will not be compared directlyon the basis of bid price per ton. The higher the specific gravity the greater will be the total tonnage of aggregate required to complete the contract. The relative influences of the different specific gravities on the cost of the total aggregate requirement have been estimated and will be added, in amounts shown below, to the

respective bid prices per ton of aggregate before award is made.

Cost to be added to bid price per ton for comparing bids.

Apparent Specific Gravity of Aggregate (Standard Definition. ASTM Designation. E-12)	Amount
Less than 2.75	$0.00
Between 2.75 and 2.85	0.04
Greater than 2.85	0.08

Spaces provided in the bidding schedule shall be filled in to show which of these limits of specific gravity will apply to the material which the bidder proposes to furnish.

It has benn determined that the use of crushed stone sand requires an additional amount of cement in the concrete to produce workability comparable to that of mixtures made with natural sand. It is estimated that $0.____ per ton of sand represents this difference in the cost of concrete, and the bid price per ton of crushed stone sand will, therefore, be increased by this amount for the purpose of comparing bids.

If the successful bidder, after being awarded a contract, furnishes a different type of sand, or a material which has a specific gravity greater or less than the limits on which the award was based, the Government reserves the right to adjust the contract unit price in accordance with the values stipulated above.

(d) A bid may be rejected if the bidder fails to furnish bid bond or to submit the data required with his bid or cannot show that he has the necessary capital & experience and owns, controls, or can procure the necessary plant to furnish the material at the time prescribed, in the specifications, and that he is not already obligated for the performance of other work which would delay the commencement, presecution, or completion of the contract contemplated in this advertisement.

(e) Any unbalanced bid which, in the opinion of the contracting officer, jeopardizes the interest of the United States will be subject to rejection for that reason.

(f) The right is reserved, as the interest of the Government may require, to reject any and all bids and to waive any informality in bids received.

13. GUARANTY. Guaranty will be required with each bid as follows: Bid Bond, Standard Form No. 24, will be executed in a penal sum not less than 10 percent of the total amount of the bid, but not exceeding $2,500,000. Individual sureties will justify in sums aggregating not less than double the penalty of the bid bond.

14. PERFORMANCE BONDS will be required as follows:

(a) A performance bond with good and sufficient surety or sureties, for the protection of the United States, Standard Form No. 25, will be executed in a penal sum not less than ten percent (10%) of the full amount of the consideration of the contract, but not exceeding $2,500,000.

15. WALSH-HEALY ACT. This procurement is subject to the provisions of the act of June 30, 1936, Public No. 846 - Seventy-fourth Congress, and the regulations adopted by the Secretary of Labor Pursuant thereto, (See Article 15 of the contract). Bidders are informed that no determination of minimum wage rates applicable to this contract have been made by the Secretary of Labor.

16. MANUFACTURER OR REGULAR DEALER. A bidder or contractor shall be deemed to be a "manufacturer" or "regular dealer" with the meaning of Section 1 (a)

of the Walsh-Healy Act if he falls within one of the following categories:

(a) A manufacturer is a person who owns, operates or maintains a factory or establishment that produces on the premises the materials, supplies, articles or equipment required under the contract and of the general character described by the specifications.

(b) A regular dealer ia a person who owns, operates or maintains a store, warehouse or other establishment in which the materials, supplies, articles or equipment of the general character described by the specifications and required under the contract are bought, kept in stock, and sold to the public in the usual course of business.

(c) Except as exempted by the Secretary of Labor, every bid received from any bidder who does not fall within one of the foregoing categories shall be rejected. The attention of bidders is directed to the publication of the United States Department of Labor entitled "Rulings and Interpretations, September 29, 1939, Walsh-Healy Public Contracts Act." This publication may be purchased from the superintendent of documents, Washington, D. C., for 10 cents. Knowledge of the contents of this publication is essential for all bidders since in addition to rulings and interpretations, it contains the rules and regulations of the Secretary of Labor published pursuant to section 4 of the law which are applicable to this invitation for bids and definitions of the terms "manufacturer" and "regular dealer." In all cases where the representations and stipulations pursuant to this law are applicable, bids submitted by others than manufacturers or regular dealers as defined in that publication will be rejected. The bidder shall here indicate the category or categories in which he qualifies:

Manufacturer ____________________

Regular dealer ____________________

17. LABOR POLICY. - Attention of bidders is invited to War Department labor policy for defense construction projects set out in memorandum of agreement approved July 22, 1941. Successful bidders will be expected to adhere to provision of the agreement, copies of which are on file at the office of the District Engineers, U. S. Engineer Office, Massena, N. Y.

18. ASSIGNMENT OF CLAIMS. The work under these specifications will be subject to the provisions of the Assignment of Claims Act of 1940 (Pub. No. 811, 76th Congress). See Article 19 of the contract.

19. PRIORITIES. A rating of _____ will be applicable to the items covered under this invitation.

20. DISCRIMINATION. Article on discrimination due to race, creed, color or national origin will be made a part of the contract, See Article 18 of the contract.

21. ADDRESS FOR BIDS. Envelopes containing bids must be sealed, marked, and addressed as follows:

Mark in upper
left-hand corner;

Bid for furnishing concrete
aggregate

Invitation No. ________
To be opened at 2 p.m., E.S.T.

Address:

To: The District Engineer
U. S. Engineer Office
Massena, New York

NOTE: See Standard Government Instructions to Bidders and copy of War Department Supply Contract Form No. 1, Bid Bond, and Performance Bond, which may be obtained upon application.

WAR DEPARTMENT
St. Lawrence River District
U. S. Engineer Office
Massena, N. Y.

Specifications: Concrete Aggregate Supply

Appropriation:

SECTION I - GENERAL PROVISIONS

1-01. SUPPLIES TO BE FURNISHED. - These specifications contemplate the furnishing and delivery of aggregate for concrete, in accordance with the provisions contained herein.

1-02. DELIVERIES. - Deliveries of the aggregates are to be made f.o.b. at the site of construction in accordance with the schedules stipulated in the contract. (See paragraph 1-04)

1-03. QUANTITIES. - An estimate of the quantities of the several sizes of concrete aggregates which will be required at the different sites is given only to serve as a basis for canvassing bids and for determining the approximate amount of the consideration of the contract. The contractor will be required to furnish sufficient quantities of the bid items for completion of the structure or structures named in the schedule, be the required quantities more or less than the amounts estimated and shown in the following table:

TABLE 1 Estimated Tonnage of Concrete Aggregates Required

Type	Sieve Size	Long Sault Dam	Long Sault Guard Gate Structure	Massena Weir	Robinson Bay Lock	Grass River Lock	Powerhouse Can. & U.S.	Totals
Fine	0 to No. 4	430,000	65,000	40,000	340,000	210,000	1,150,000	2,235,000
Coarse	3/16" to 3/4"	180,000	49,000	30,000	253,000	159,000	730,000	1,401,000
Coarse	3/4" to 1½"	175,000	49,000	29,000	253,000	160,000	730,000	1,396,000
Coarse	1½" to 3"	320,000	42,000	25,000	220,000	137,000	720,000	1,464,000
Coarse	3" to 6"	250,000					220,000	470,000
Total Coarse Aggregate		925,000	140,000	84,000	726,000	456,000	2,400,000	4,731,000
Total Fine and Coarse		1,355,000	205,000	124,000	1,066,000	666,000	3,550,000	6,966,000

1-04. COMMENCEMENT, PROSECUTION AND COMPLETION.

(a) After notice to proceed, the contractor will be allowed a minimum of ninety calendar days to start delivery. Thereafter, the contracting officer will notify the contractor of the amount or amounts to be delivered at each project. The contractor shall accept cancellation of any shipment provided such notice of cancellation has been received by him by telephone, telegraph, or in writing at his processing plant at least 24 hours prior to the normal time of dispatch of shipments.

(b) (1) The schedule of work on this contract will correlate with the schedule of work by construction contracts. The aggregate quantities required at each destination at any particular time will be contingent on the progress of construction. The anticipated maximum rate of the delivery of aggregates to each construction unit and the approximate dates for the start and completion of delivery are shown in Table II. Deliveries, in general, shall be made in accordance with this schedule. If it is anticipated that weather conditions may cause a suspension in delivery of materials, a sufficient quantity of aggregates will be required to be stock piled at the site, or sites, of work during favorable weather conditions to insure the required construction progress.

Table II - Start of Shipment and Rate of Delivery

Construction Unit	Aggregate Type	Estimated Total Tonnage Req'd.	Estimated Maximum Quantity Required to be Delivered within Period of Time Indicated: One Month (Tons)	One Month (% of Total)	One Year (Tons)	One Year (% of Total)	Date Start of Delivery	Date finish of Delivery
Long Sault Dam	Fine	430,000	24,000	5½	175,000	41		
	Coarse	925,000	50,000	5½	400,000	43		
Long Sault Canal Guard Structure	Fine	65,000	10,000	15½	65,000	100		
	Coarse	140,000	22,000	15½	140,000	100		
Massena Weir	Fine	40,000	6,000	15	40,000	100		
	Coarse	84,000	13,000	15	84,000	100		
Robinson Bay Lock	Fine	340,000	24,000	7	220,000	65		
	Coarse	726,000	50,000	7	270,000	65		
Grass River Lock	Fine	210,000	15,000	7	137,000	65		
	Coarse	456,000	32,000	7	298,000	65		
Powerhouse (U.S.& Canadian)	Fine	1,150,000	58,000	5	575,000	50		
	Coarse	2,400,000	120,000	5	1,200,000	50		

(2) In case of failure on the part of the contractor to meet the delivery schedule established under the provisions of paragraph 1-04 (b) (1), the contractor shall pay to the Government as liquidated damages the sum of five cents (5¢) per ton of aggregate for each calendar day the contractor is behind in his deliveries, except when delay is excused under the provisions of the contract.

(c) Method of Shipment.

Only hopper type, bottom-dump railroad cars with gates, will be acceptable for rail shipment of concrete aggregates.

(d) Protection - All cars used for shipment of aggregates shall be clean and have no openings through which materials may be lost. When loading from chutes, the center ridge of material shall not extend more than 9 inches above the top of the car, and a freeboard of 6 inches shall be provided by the sidewalls of the car, when so loaded.

(e) Sundays, Holidays and Nights. - Production and shipping of aggregate on Sundays, holidays, and nights will be at the option of the contractor. However, when the contractor elects to load material at such times, notice of his intention to do so shall be given the contracting officer within a reasonable time in advance thereof.

1-05 MEASUREMENT AND PAYMENT

of Quantities.

(a) Measurement/ The quantities of concrete aggregates to be paid for under the several items shall be the number of tons of 2000 pounds, dry weight, delivered in accordance with these specifications and the orders of the contracting officer. The aggregates shall be weighed on certified scales. The tare weight of each car used in this service shall be obtained monthly or as the contracting officer may determine. The contractor shall provide the contracting officer, upon request, with a certificate of accuracy of the scale as determined by a public weigher. All expense of weighing shall be borne by the contractor and shall be included in the bid prices. All cars shall be weighed in the presence of a representative of the Government, who will make tests for corrections for moisture in the aggregate. No payment shall be made for any aggregate shipped in the absence of such a representative.

(b) Method of Payment.

(1) Payments will be made at the contract unit price per short ton (2,000 lbs.) for the various types of aggregates indicated in the Schedule of Bid Items.

(2) Payments will be made, with discounts deducted, within the number of days prescribed by the contractor in his bid after receipt of material at at destination or receipt of invoice, whichever date is later. Date of mailing check will be considered as date of payment. If for any reason it is necessary to return vouchers or invoices to the contractor for signature or correction before payment, the discount period with respect to such vouchers or invoices shall be determined from the date the vouchers or invoices, properly executed, are again received by the contracting officer.

(3) An invoice shall be made out for each individual shipment, showing the name and location of the plant, date shipment left plant, railroad routing, number of cars included in the shipment, tons of aggregate loaded in each car, and the total tons in the shipment. Two copies of these invoices shall be mailed to the contracting officer on the date of shipment. The pay quantities, in tons, shall be based on net weight of the aggregate adjusted for moisture content, based on average determinations made by the Government inspector. Copies of such routine moisture determinations will be furnished the contractor daily or oftener as the need may arise.

(4) Invoice Certification. - The following certificate must be typed or stamped verbatim on the face of each copy of the invoice. This invoice must be signed by a member of the firm on the original copy of the invoice only:

I certify that the above bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with; and that State or local sales taxes are not included in the amounts billed.

____
(Firm Name)

By __________________________

Title ________________________

1-06 ESCALATOR CLAUSE.

(a) The following terms used hereafter are defined as follows:

(1) "Basic hourly earnings index" shall be determined by adding monthly average hourly earnings in the "________" industry as indicated under heading "____________________" in the monthly pamphlet "Hourly Wages and Labor Employment" issued by the Department of Labor for: the month in which contract time commences, the five (5) months preceding such month, and the six (6) months succeeding such month; and then dividing this total by twelve (12).

(2) "Basic materials index" shall be determined by method in (1) above, using monthly indices for item "_____________" in the monthly pamphlet "Wholesale Prices" issued by the Department of Labor.

(3) "Monthly labor adjustment index" shall be determined from monthly average hourly earnings identified as to source in (1) above as follows: Add the average hourly earnings for the month for which adjustment is being made, the two preceding months and the two succeeding months; and then divide this total by five (5).

(4) "Monthly materials adjustment index" shall be determined by method in (3) above, using monthly indices identified as to source in (2) above.

(5) Above contract indices in (1), (2), (3), and (4) shall be computed to nearest second decimal place, taking the decimal point as located in indices issued by the Department of Labor. When third decimal place computes to 5 or over, the figure in second decimal place shall be raised to next higher figure.

(b) (1) The proportion of the contract price represented by labor, subject to adjustment in price, is accepted as _____________ per cent of the contract price.

(2) The proportion of the contract price represented by materials, subject to adjustment in price, is accepted as _____________ per cent of the contract price.

(c) (1) The labor cost for entire contract as determined in (b) (1) above shall within thirty (30) days after receipt of notice to proceed, be divided into monthly labor cost quotas, prepared by the contractor and subject to the approval of the contracting officer, for each partial or whole calendar month of the contract time beginning with the notice to proceed.

(2) The materials cost for entire contract as determined in (b) (2) above shall be similarly divided into monthly materials cost quotas within thirty (30) days after receipt of notice to proceed.

(d) Adjustments in payments shall be obtained for each monthly cost quota as follows: - Multiply monthly cost quota by the appropriate monthly adjustment index, divide by corresponding basic index, and subtract monthly cost quota. The result shall be added to or deducted from payments to the contractor.

(e) (1) If the time for performance of this contract is legally extended by the contracting officer, there shall be immediately set up by the contractor, subject to the approval by the contracting officer, new monthly cost quotas as necessary. These new monthly cost quotas may extend back as far as any month for which adjustments in payments have not been completed, but the total of the new quotas shall not exceed the total of the old quotas for which adjustments in payments have not been completed.

(2) If there is an increase or decrease in the work originally contemplated under this contract, there shall be immediately set up by the contractor, subject to the approval of the contracting officer, new monthly costs quotas for months concerned.

(3) If liquidated damages are assessed against the contractor under the contract, such liquidated damages shall not be considered in making adjustments.

(f) The adjustment payment or deduction for any one month shall normally be included with next partial contract payment after receipt of Department of Labor indices for such month.

(g) The acceptance and final payment for work and/or materials under this contract shall be carried out as elsewhere provided in this contract, and amounts retained for the protection of the government during construction shall be promptly paid upon final acceptance: Provided, however, that an amount, as determined by the contracting officer, for protection of the government in adjustments not yet completed, shall be retained; and, provided further, that the release required by ______________ will contain provision excepting such adjustment payments as may become due the contractor.

(h) After final payment for basic contractural price as indicated in paragraph 7 above has been made, adjustments becoming due will be delayed until all indices necessary for completion of all adjustments under the contract are available, when one lump payment or deduction shall be made for such adjustments.

(i) In case the final adjustment in the contract price results in a net deduction from the contract price, the contractor and his sureties shall be liable for the amount thereof until it is refunded to the Government.

(j) When payment obligations under the contract exceed the contract price as a result of increases in labor and/or materials costs to the extent that available appropriations are exhausted, the Government reserves the right, without further liability to suspend further work under the contract for the account of the Government or to terminate the contract on payment of contractual obligations incurred up to the point of termination.

1-07 CONCRETE AGGREGATE SOURCES.

(a) Investigations are being conducted by the contracting officer to locate suitable aggregate sources, and laboratory tests on fine and coarse aggregate are being made. It shall be the responsibility of the contractor to locate sources of aggregate meeting the specifications, but the results of all explorations, investigations, and laboratory tests directed by the contracting officer, will be made available to bidders at the U. S. Engineer Office, Massena, N. Y.

(b) Should deposits of satisfactory aggregate be located within the Government-controlled area in the reservoir or adjacent to the site they may be considered in submitting bids after receipt of approval of the contracting officer, who will make this information known to all bidders. No charge will be made to the contractor for materials authorized to be taken from Government-controlled lands and used in the work covered by these specifications, but all pits shall be left in a neat and sightly condition, and all pits above the normal ground water table shall be adequately drained. Side slopes shall be not steeper than 1 on 3. No separate payment will be made for such work.

(c) Approval of aggregate sources by the contracting officer shall not constitute approval of all materials taken from deposits and the contractor will be responsible for the quality of all materials furnished.

(d) Should the contractor obtain aggregate material from deposits on private lands he shall pay any royalties or other charges required, and the contracting officer assumes no responsibility for such use and the Government will not be obligated in any way.

1-08. ORGANIZATION, PLANT, AND PROGRESS.

(a) The contractor shall employ an ample force of properly experienced men and provide an aggregate plant or plants properly adapted to the work and of sufficient capacity and efficiency to accomplish the work in a safe and workmanlike manner at the rate of progress specified. All production equipment shall be maintained in good working order and provision shall be made for immediate emergency repairs. It is understood that award of this contract shall not be construed as a guaranty by the United States that plant listed in statement of contractor for use on this contract is adequate for the performance of the work.

(b) In the event any of the provisions of the contract are violated by the contractor or any subcontractor, the contracting officer may terminate the contract and purchase similar materials in the open market or otherwise, and the contractor and his sureties shall be liable to the Government for any excess cost occasioned the Government thereby.

1-09. LIABILITY AND SAFETY REQUIREMENTS.

(a) The contractor will not be allowed to block or obstruct any public highway without having secured prior permission from the contracting officer, and having provided safe temporary detours. During the time the public highways may be so blocked, the contractor shall place danger lights, barricades, and warning signs in accordance with the laws of the State of New York.

(b) The contractor shall be responsible that his employees strictly observe the laws of the United States affecting all operations under this contract. He shall comply with all applicable Federal, State, and local laws, including those concerning the inspection of boilers and other equipment and the licensing of engineers and other employees.

(c) The contractor shall conduct the work with due regard to adequate safety and sanitary requirements and shall maintain his plant and equipment in safe condition. He shall be responsible for injury to his employees and to those of the Government that occur as a result of his fault or negligence. He shall conform to current safety engineering practices as set forth in the manual of Accident Prevention in Construction, published by the Associated General Contractors of America; the publications of the National Safety Council; and with all applicable State or local safety and sanitary laws, regulations, and ordinances.

(d) The contracting officer will require such safety and sanitary measures to be taken as the nature of the work, and the conditions under which it is to be performed, demand. Such measures shall, where applicable, include:

(1) Adequate fire prevention measures and fire-fighting equipment.
(2) Adequate life protection and life-saving equipment.
(3) Adequate illumination during night operations.
(4) Instruction in accident prevention to reach all employees.
(5) Watchman service at hazardous railroad crossings.
(6) Such machinery guards, safe walkways, scaffolds, ladders, bridges, gang planks, and other safety devices, equipment, and apparel as may be required by the contracting officer as requisite to the prevention of accidents.

(7) The contractor shall furnish, to his employees and the employees of the Government located at his plant, a sufficient supply of potable drinking water. The drinking water shall be tested periodically in the State or other approved laboratories and shall at all times meet the State Board of Health's requirements for potable drinking water.

(e) The contractor shall promptly report to the contracting officer, in form prescribed by him, all accidents occuring at the site of the work.

(f) The contracting officer will notify the contractor in writing of any noncompliance with the foregoing provisions and the corrective action to be taken. If the contractor fails or refuses promptly to comply, the contracting officer may issue a stop order suspending all or any part of the work. Such stop order shall be sent by registered mail to the contractor and shall be accepted by him as sufficient notice thereof. Work will thereupon be suspended as directed. When satisfactory corrective action is taken, a resumption order will be issued. No part of the time lost due to any such stop order shall be made the subject of a claim for extension of time or for excess costs or damages by the contractor.

(g) The contractor shall provide first aid station facilities, with suitable personnel conveniently located with respect to his operations.

1-10. LIGHTS. - The contractor shall, at his own expense, display proper lights continuously each night, between the hours of sunset and sunrise and during fogs, upon all moving plant equipment connected with the work, and shall be responsible for all damages resulting from any neglect or failure in this respect. If work is done at night the contractor shall maintain, from sunset to sunrise, such lights on or about his plant as the contracting officer may deem necessary for the proper observation of the operations.

1-11. USE OF EXPLOSIVES. - The contractor shall use the utmost care in the use of explosives necessary for the prosecution of the work, not to endanger life or property. All blasting operations shall be conducted by experienced men only. The handling and use of explosives shall be done strictly in accordance with the latest methods and ruling to insure safety; in accordance with the specifications issued by the U. S. Bureau of Mines; and in compliance with the local and State laws. Failure to observe necessary precautions will be sufficient grounds for temporary suspension of the work. All explosives shall be transported and stored in a secure manner, and in accordance with local and State laws; all vehicles and such storage places shall be marked clearly "DANGER - EXPLOSIVES," and shall be in the care of competent watchmen at all times. In no case shall caps or other detonators be stored or transported with dynamite or other explosives. The location of magazines for the storage of explosives and for the separate storage of detonators shall be subject to the approval of the contracting officer.

1-12. PROPERTY DAMAGE. - Damage to Government property or to the works due to failure of the contractor to carry out the terms of the contract and specifications, to take reasonable precautions, or to maintain progress to approved schedules, or to carry out the instructions of the contracting officer shall be made good by the contractor without expense to the United States. He will also be held responsible for any damage done to adjoining property through his neglect or failure to take proper precautions.

1-13. INSPECTION

(a) All aggregate furnished under these specifications will be inspected as provided in paragraph 2-01.

(b) Should the contractor refuse, neglect or delay compliance with

the requirements concerning facilities for inspection, the specific facilities may be furnished and maintained by the contracting officer, and the cost thereof deducted from any amounts due or to become due the contractor.

(c) Except as specified in this paragraph and in Article 4 of the contract all expenses of inspection will be borne by the United States.

(d) The contractor shall furnish a suitable room containing at least 200 square feet of floor space for a Government laboratory to be used for temporary storage and testing of the aggregates. This room shall be protected from the weather, properly lighted, provided with necessary work tables and benches, and shall be heated in cold weather. The location for this room shall be subject to the approval of the contracting officer. The contractor shall provide electricity for light and miscellaneous uses, and an adequate supply of water for drinking and sanitary purposes.

1-14. CHANGES AND CHANGED CONDITIONS. - When changes are made in the specifications or changed conditions are encountered during the progress of the work which cause an increase or decrease in the amount due under the contract, or in the time required for its performance, an equitable adjustment shall be made in accordance with Article 2 of the contract.

1-15. MINOR MODIFICATIONS. - The right is reserved to make such minor changes in the execution of the work to be done under these specifications as, in the judgment of the contracting officer, may be necessary or expedient to carry out the intent of the contract; provided, that the unit cost to the contractor of doing the work shall not be increased thereby, and no increase in unit price over the contract rate will be paid to the contractor on account of such changes. (See Articles 2 and 3 of the contract).

1-16. CLAIMS, PROTESTS, AND APPEALS. - If the contractor considers any work demanded of him to be outside the requirements of the contract or if he considers any action or ruling of the contracting officer or of the inspectors to be unfair, the provisions of Article 12 of the contract shall apply.

1-17. PATENTS. - The contractor shall hold and save the Government, its officers, agents, servants, and employees, harmless from liability of any nature or kind, including costs and expenses for or on account of any patented or unpatented invention, article or appliance manufactured or used in the performance of this contract, including their use by the Government.

1-18. INTERFERENCE WITH OTHER CONTRACTORS. - The contractor shall not interfere with material, appliances or workmen of the United States or of any other contractor. As far as practicable, all contractors shall have equal rights to the use of all roads, grounds and adjacent river and make equitable agreements among themselves for the use of temporary railroads and highways. In cases of disagreement regarding such use, the decision of the contracting officer shall govern.

1-19. SUBCONTRACTORS. - Subcontractors and their employees shall be considered to be employees of the contractor as the term "employee" is used in these specifications.

1-20. DOMESTIC ARTICLES. - Because the materials listed below, or the materials from which they are manufactured are not mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, their use in the manufacture of the supplies herein specified (subject to the requirements of the specifications)

is authorized without regard to the country of origin (See Article 13 of the contract).

Abrasives
Acetic Acid
Acetic Anhydride
Acetene
Aconite Root
Alcohol, Ethyl
Alpha Cellulose
Aluminum
Aniline
Antimony (and ores)
Argols and Wine Lees
Arsenic
Asbestos
Balsa
Barium Chemicals
Bauxite
Belladonna Leaves
Beryl Ores
Bismuth (and ores)
Bristles, Hog
Belladonna Roots
Cadmium (and ores)
Calcium
Camphor
Castor Beans
Castor Oil
Chlorine
Chromium (and ores)
Cobalt (and ores)
Cocoa (or cocao) Beans
Coconut Oil
Coconut Shell Char
Coffee
Columbium and Ores
Copper (and ores)
Copra
Cork
Cotton, Long Staple
Cotton Linters
Cresols and Cresylic Acid
Cryolite
Cube or Timbo Root
Derris Root
Diamond Dies
Diamonds, Industrial
Ergot of Rye
Tin (and Ores)
Methanol
Mica
Mohair
Molasses
Molybdenum (and Ores)
Naphthalene

Ferrosilicon
Fish Liver Oils
Fish Oils
Flax
Flaxseed
Fluorspar
Formaldehyde
Gasoline, Aviation,
100 Octane
Glass, Optical
Glass, Scientific
Glycerine
Graphite
Gume and Resins, Natural
Gypsum
Helium
Hemp
Henbane Leaves
Henequen
Hides (and Skins)
Ilmenite
Iodine
Iridium (and Ores)
Iron Ore
Iron and Steel
Jute Burlaps
Jute, Unmanufactured
Kapok
Lac and Shellac
Lead (and Ores)
Leather
Lignum Vitae
Linseed Oil
Magnesite
Magnesium
Mahogany
Manganese, Ferrograde
(and Ores)
Manganese and Ores
Manila Fiber
Mercury (and Ores)
Sulfuric Acid
Tanning Materials
Tantalum and Ores
Teak
Tea Waste
Quartz Crystal
Quinine (and Cinchona Bark)
Radium and Ores
Rayon
Red Squill
Refractory Materials
Rotenone Root

Neatsfoot Oil
Nickel (and Ores)
Nitrogen Compounds
(Including Ammonia, Nitric Silk
Acid and Chilean Nitrates Sisal
Nux Vomica
Oiticica Oil
Opium
Palm Oil
Paper and Pulp
Petroleum and Petroleum
Products
Phenol
Phosphate Materials
Phosphorus
Phthalic Anhydride
Platinum (and Platinum
Group) (and Ores)
Polyvinyl Chloride
Potash
Pyrethrum Flowers
Pyrites

Rubber
Rutile
Senna Leaves
Silk
Sisal
Stramonium Leaves
Strontium and Ores
Strontium Chemicals
Sugar
Sulphur
Tungsten (and Ores)
Uranium and Ores
Vanadium (and Ores)
Wool
Zinc (and Ores) and Zinc
Concentrates
Titanium and Ores
Toluol
Tung Nuts
Tung Oil
Zinc Oxide
Zirconium (and Ores)

SECTION II - TECHNICAL PROVISIONS

2-01. GENERAL. - The concrete aggregate as received at destinations shall conform in all respects to the requirements of these specifications. However, for the convenience of the contractor and in order to facilitate the wasting of any unsatisfactory material prior to shipping, inspection will be made at the site of production and any aggregate which fails to meet all of the requirements will thereupon be rejected. Routine control tests and analyses of the aggregates in their various states from raw to finished products will be made by the Government, and the contractor shall provide such facilities as the contracting officer may consider necessary for the ready procurement of representative samples.

2-02. FINE AGGREGATE.

(a) Composition. - Fine aggregate shall be natural sand or crushed stone sand. If crushed stone sand is furnished it shall be manufactured from material which has been crushed to pass the 3" square mesh screen and be retained on a ½" square mesh screen. Tailings from this preliminary crushing and screening will not be accepted. Only clean dense, tough, durable dolomite stone, or other material of equal or greater stability will be acceptable for artificial sand manufacture.

(b) Grading.

(1) The fine agregate shall be well graded from coarse to fine and when tested by means of U. S. Standard square mesh sieves shall fall within the following limits of gradation:

Sieve Size	Percent Passing, by Weight: Natural Sand	Percent Passing, by Weight: Crushed Stone Sand
3/8"	100	100
No. 4	95-100	95-100
" 8	75-90	80-95
" 16	50-75	55-80
" 30	30-55	30-60
" 50	12½-25	15-30
" 100	3.5-8	5 -12

(2) If natural sand is furnished the fineness modulus shall be not less than 2.50 nor more than 3.00; if crushed stone sand is furnished the fineness modulus shall be not less than 2.40 nor more than 2.90; and in either case the fineness modulus of the sand shipped to any one delivery point shall not vary more than 0.20 from lowest to highest.

(3) Any classifying, blending, screening, washing or other treatment of the fin aggregate required to meet these specifications shall be done by the contractor and the cost thereof shall be included in the unit prices bid for aggregate delivered f.o.b. destination.

(4) Deficiencies in the quanitities passing the #50 and #100 sieves may be compesated for by furnishing, through separate shipment and at the contractors expense, a sufficient quantity of fine dune sand of approved quality and grading. This quantity shall not exceed 15 percent by weight of the total fine agregate.

(c) Deleterious Substances. - The substance designated shall not be present in excess of the following amounts:

	Percent by Weight
Clay lumps - - - - - - - - - - - - -	1
Material removed by decantation-	3
Shale - - - - - - - - - - - - - - -	1

(d) Mortar Strength. - Mortar specimens made with the fine aggregate shall have a compressive strength at 28 days of at least 90 percent of the strength of similar specimens made with Ottawa sand having a fineness modulus of 2.40 + 0.10 and with the same cement.

(e) Tests. - Fine aggregates will be subjected to the following tests:

(1) Freezing and thawing test performed in accordance with A.S.T.M. Specification C137 - 38T. "Soundness of Aggregates by Freezing and Thawing," shall not show a loss in 25 cycles of more than 5 percent, or not more than that shown by sand of proven quality.

(2) Magnesium sulphate accelerated soundness test performed in accordance with A.S.T.M. Specification C88 - 39T, "Soundness of Aggregates by use of Sodium Sulphate or Magnesium Sulphate," shall not show a loss in 10 cycles of more than 10 percent.

(f) Organic Impurities. - The fine aggregate when tested in accordance with the A.S.T.M. Standard Method of Test for Organic Impurities in Sand for concrete (A.S.T.M. Designation (C 40-33) shall not show a color darker than the standard.

2-03. COARSE AGGREGATE.

(a) Composition. - Coarse aggregate shall be washed gravel or crushed stone.

(b) Quality. - Coarse aggregate shall consist of hard, tough and durable particles free from adherent coating. It shall contain no vegetable matter nor soft, friable, thin or elongated particles in quantities considered deleterious by the contracting office. Aggregate which has disintegrated or weathered badly under exposure conditions similar to those which will be encountered by the work under consideration, shall not be used. The substances designated below shall not be present in excess of the following amounts:

Soft particles (including shale) - -	5%
Clay lumps - - - - - - - - - - - - - -	0.25%
Removed by decantation - - - - - - - -	1%
Thin elongated particles - - - - - -	10%

When the material removed by decantation consists essentially of crusher dirt the maximum amount permitted may be raised to 1-1/2 percent. When crushed stone is used the crushed shall be equipped with a screening system which will separate the dust from the stone and convey it to a separate bin.

(c) Size and Gradation.

(1) Coarse aggregate shall be generally rounded or cubical in shape, and well graded from fine to coarse within each designated size range so that concrete of the required workability, density, and strength can be made without the use of an excess amount of sand, water, or cement.

Coarse aggregate shall be separated, and the specified sizes delivered separately in accordance with the following:

3/16"	to 3/4"	(Square Mesh Screen)
3/4"	to 1-1/2"	" " "
1-1/2"	to 3"	" " "
3"	to 6"	" " "

Within any of the above-indicated size limits, not less than 85 percent shall be retained on a standard square mesh screen of the minimum size aggregate indicated, and 100 percent shall pass a mesh screen 1-1/2 times the maximum size aggregate indicated.

(d) Tests. - Coarse aggregates will be tested and shall be subjected to the following:

(1) Freezing and thawing test performed in accordance with A.S.T.M. Specification C137 - 38T, "Soundness of Aggregates by Freezing and Thawing," shall not show a loss in 25 cycles of more than 5 percent.

(2) Magnesium sulphate accelerated soundness test performed in accordance with A.S.T.M. Specification C88 - 39T, "Soundness of Aggregates by use of Sodium Sulphate or Magnesium Sulphate," shall not show a loss in 10 cycles of more than 10 percent.

2-04. SAMPLING AND TESTING AGGREGATES. - Except where provided otherwise by these specification, all sampling and testing of aggregates shall be made in accordance with the Federal Specifications. Unless specified otherwise, all test samples shall be supplied by the contractor at his expense and all tests will be made by and under the supervision of the Government at its expense. The source form which concrete aggregates are to be obtained shall be selected by the contractor well in advance of the time when they will be required in work, and suitable samples, as they are to be used in the concrete, shall be furnished to the contracting officer at least 30 days in advance of the time when delivery of the aggregate is expected to begin.

Standard Form No. 31 Invitation No. ______

STANDARD GOVERNMENT FORM OF BID

(SUPPLY CONTRACT)

ORIGINAL) Indicate which
DUPLICATE) by erasure

Opening Date of this Bid

............M., ..., 19......

(Date) ____________________

To The District Engineer,
U. S. Engineer Office,
Massena, New York

1. In compliance with your invitation for bids to furnish materials and supplies listed on the reverse hereof or on the accompanying schedules, numbered: "A" to "R" inclusive, the undersigned, ____

____

a corporation organized and existing under the laws of the State of ______________________ a partnership consisting of

____

an individual trading as ______________________

of the city of ______________________

hereby proposes to furnish, within the time specified, the materials at the prices stated opposite the respective items listed on the schedules and agrees upon receipt of written notice of the acceptance of this bid within ________ days (60 days if no shorter period be specified) after the date of opening of the bids, to execute, if required, (War Department Supply Contract Form No. 1) in accordance with the bid as accepted, and to give bond, if required, with good and sufficient surety or sureties, for the faithful performance of the contract, within 10 days after the prescribed forms are presented for signature.

Discount will be allowed for prompt payment as follows:

10 calendar days __________percent; 20 calendar days __________percent;
30 calendar days __________percent; or as stated in the schedules.

(Time will be computed from date of the delivery of the supplies to carrier when final inspection and acceptance are at point of origin, or from date of delivery at destination or port of embarktion when final inspection and acceptance are at those points, or from date correct bill or voucher properly certified by the contractor is received if the latter date is later than the date of delivery.)

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
	SCHEDULE "A" - FINE AGGREGATE FOR LONG SAULT DAM			
1	Natural Sand	430,000		
1a	Crushed Stone Sand	430,000		
	SCHEDULE "B" - FINE AGGREGATE FOR LONG SAULT CANAL GUARD STRUCTURE			
2	Natural Sand	65,000		
2a	Crushed Stone Sand	65,000		
	SCHEDULE "C" - FINE AGGREGATE FOR MASSENA CANAL WEIR			
3	Natural Sand	40,000		
3a	Crushed Stone Sand	40,000		
	SCHEDULE "D" - FINE AGGREGATE FOR ROBINSON BAY LOCK			
4	Natural Sand	340,000		
4a	Crushed Stone Sand	340,000		
	SCHEDULE "E" - FINE AGGREGATE FOR GRASS RIVER LOCK			
5	Natural Sand	210,000		
5a	Crushed Stone Sand	210,000		
	SCHEDULE "F" - FINE AGGREGATE FOR POWERHOUSE STRUCTURES			
6	Natural Sand	1,150,000		
6a	Crushed Stone Sand	1,150,000		

SCHEDULE "G" - FINE AGGREGATE, COMBINATION BID
Natural Sand Only. Bid on Any Two or More Items Shown

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
7	Natural Sand for Long Sault Dam	430,000		
8	" " " L.S.Canal Guard Str.	65,000		
9	" " " Massena Weir	40,000		
10	" " " Robinson Bay Lock	340,000		
11	" " " Grass River Lock	210,000		
12	" " " Powerhouse Strs.	1,150,000		

SCHEDULE "H" - FINE AGGREGATE, COMBINATION BID
Crushed Stone Sand Only. Bid on Any Two or More Items Shown

7a	Crushed Stone Sand for Long Sault Dam	430,000		
8a	" " " " L.S.Canal Guard Str	65,000		
9a	" " " " Massena Weir	40,000		
10a	" " " " Robinson Bay Lock	340,000		
11a	" " " " Grass River Lock	210,000		
12a	" " " " Powerhouse Strs.	1,150,000		

SCHEDULE "I" - COARSE AGGREGATE FOR LONG SAULT DAM

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
13	Natural Gravel	925,000		
13a	Crushed Stone	925,000		

SCHEDULE "J" - COARSE AGGREGATE FOR LONG SAULT CANAL GUARD STRUCTURE

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
14	Natural Gravel	140,000		
14a	Crushed Stone	140,000		

SCHEDULE "K" - COARSE AGGREGATE FOR MASSENA WEIR

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
15	Natural Gravel	84,000		
15a	Crushed Stone	84,000		

SCHEDULE "L" - COARSE AGGREGATE FOR ROBINSON BAY LOCK

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
16	Natural Gravel	746,000		
16a	Crushed Stone	746,000		

SCHEDULE "M" - COARSE AGGREGATE FOR GRASS RIVER LOCK

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
17	Natural Gravel	456,000		
17a	Crushed Stone	456,000		

SCHEDULE "N" - COARSE AGGREGATE FOR POWER HOUSE STRUCTURES

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
18	Natural Gravel	2,400,000		
18a	Crushed Stone	2,400,000		

SCHEDULE "O" - COARSE AGGREGATE, COMBINATION BID
Natural Gravel Only. Bid on Any Two or More Items Shown

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
19	Natural Gravel for Long Sault Dam	925,000		
20	" " " L.S.Canal Guard Str.	140,000		
21	" " " Massena Weir	84,000		
22	" " " Robinson Bay Lock	746,000		
23	" " " Grass River Lock	456,000		
24	" " " Powerhouse Strs.	2,400,000		

SCHEDULE "P" - COARSE AGGREGATE, COMBINATION BID
Crushed Stone Only. Bid on Any Two or More Items Shown

19a	Crushed Stone for Long Sault Dam	925,000		
20a	" " " L.S. Canal Guard Str.	140,000		
21a	" " " Massena Weir	84,000		
22a	" " " Robinson Bay Lock	746,000		
23a	" " " Grass River Lock	456,000		
24a	" " " Powerhouse Strs.	2,400,000		

SCHEDULE "Q" - FINE AND COARSE AGGREGATE, COMBINATION BID.

Bid on Any or All Items of Fine Aggregate and Any or All Items of Coarse Aggregate.

Item No.	Designation	Quantity (Tons)	Unit Price	Amount
25	Natural Sand for Long Sault Dam	430,000		
26	" " " Long S.C. Guard Str.	65,000		
27	" " " Massena Weir	40,000		
28	" " " Robinson Bay Lock	340,000		
29	" " " Grass River Lock	210,000		
30	" " " Powerhouse Strs.	1,150,000		
31	Natural Gravel for Long Sault Dam	925,000		
32	" " " L.S. Canal Guard Str.	140,000		
33	" " " Massena Weir	84,000		
34	" " " Robinson Bay Lock	746,000		
35	" " " Grass River Lock	456,000		
36	" " " Powerhouse Strs.	2,400,000		
25a	Crushed Stone Sand for Long Sault Dam	430,000		
26a	" " " " L.S.Canal Guard Str.	65,000		
27a	" " " " Massena Weir	40,000		
28a	" " " " Robinson Bay Lock	340,000		
29a	" " " " Grass River Lock	210,000		
30a	" " " " Powerhouse Strs.	1,150,000		
31a	Crushed Stone Coarse Aggregate for Long Sault Dam	925,000		
32a	" " C.A. for Long S.C.Guard Str.	140,000		
33a	" " C.A. for Massena Weir	84,000		
34a	" " C.A. for Robinson Bay Lock	746,000		
35a	" " C.A. for Grass River Lock	456,000		
36a	" " C.A. for Powerhouse Strs.	2,400,000		

(a) All amounts and totals given above will be subject to verification by the United States. In case of variation between unit bid price and totals shown by bidder, the unit price will be considered to be his bid.

(b) The quantities of each item of the bid, as finally ascertained at the close of the contract, in the units given and the unit prices of the several items stated by the bidder in the accepted bid, will determine the total payments to accrue under the contract. The unit price bid for each item must allow for all collateral or indirect cost connected with it.

(c) The limits of the apparent specific gravity for each aggregate proposed to be furnished are indicated below. (The bidder will list all of the bid item numbers in appropriate columns).

Applicable limits of apparent Specific Gravity.

Less than 2.75	2.75 to 2.85	Greater than 2.85
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.
Item No.	Item No.	Item No.

2. (a) Federal Taxes. Bidder will indicate by check mark which <u>one</u> of the following statements is applicable to his bid:

a. Prices herein do not include any federal taxes imposed by Title IV of the Revenue Act of 1932, as amended..

b. Prices herein include the federal taxes imposed by Title IV of the Revenue Act of 1932, as amended, but consent is hereby given to the deduction of said taxes and the acceptance of a tax exemption certificate in lieu thereof.

c. Prices herein include the federal taxes imposed by Title IV of the Revenue Act of 1932, as amended.

(Whenever statement (a) or (b) above is applicable, bidder will state the amount of the taxes involved as to each item for which a tax exemption certificate will be required.)

(b) State or Local Taxes. Bidder will indicate by check mark which <u>one</u> of the following statements is applicable to his bid:

a. Prices herein do not include any state or local taxes imposed directly on the sale of the supplies.

b. Prices herein include all state and local taxes imposed directly on the sale of supplies, but consent is hereby given to the deduction of said taxes and the acceptance of a tax exemption certificate in lieu thereof.

c. Prices herein include all state and local taxes imposed directly on the sale of the supplies, but no deduction of said taxes will be permitted nor will a tax exemption certificate be accepted in lieu thereof.

(Whether state or local taxes charge directly on the sale of goods are included or are not included, the amount of such taxes should be shown in detail.)

3. <u>EXPERIENCE.</u>

4. <u>STATEMENT ESTABLISHING PERMANENT PLACE OF BUSINESS AND FINANCIAL STATUS.</u> (See Invitation for Bids.)

5. PLANT TO BE USED ON THE WORK. (See Invitation for Bids and paragraph 1-08 of the specifications.)

Equipment available for aggregate supply.

No.	Type	Manufacturer	Capacity	Age	Condition

(Witness to signature

(Full name of bidder)

(Address)

Note.- See Standard Government Instructions to Bidders and copy of the Contract, Bid Bond, and Performance Bond, which may be obtained upon application.

PART TWO

CONCRETE AGGREGATE INVESTIGATION

CONCRETE AGGREGATE INVESTIGATION
ST. LAWRENCE RIVER PROJECT

TABLE OF CONTENTS

Subject | Page

CONCRETE AGGREGATE INVESTIGATION
ST. LAWRENCE RIVER PROJECT

INTRODUCTION

The concrete materials required for the construction of the St. Lawrence River Project were estimated to include 2,500,000 tons of fine aggregate and 5,500,000 tons of coarse aggregate. Explorations for locating sources to supply these needs were started in January, 1941, and carried continuously forward until December of the same year. Factors which determined the scope of the aggregate investigation were the quantity of material required, the high standard of quality necessary to produce durable concrete, and the lack of adequate service records for most of the materials available.

At the time the survey was begun, letters of inquiry regarding aggregate deposits were sent to neighboring U. S. Engineer Districts; state and county highway engineers; Canadian Department of Public Works; and to many commercial agencies in New York and Canada. The data obtained were supplemented by personal interviews, and all of the aggregate deposits reported were inspected by representatives of this office. The field reconnaissance and explorations covered Canadian sources from Kingston and Perth, Ontario, on the west to Montreal and Joliette, Quebec, on the east; and Northern New York sources from Oswego and Boonville on the southwest to Saranac Lake and Lyon Mountain on the southeast. The geology of natural sand and gravel deposits and stone formations in the region of Northern New York and Southern Canada, bordering the St. Lawrence River, is given under the heading "Regional Geology" in this appendix.

The sand and gravel deposits and rock outcrops, located both in the United States and in Canada, are shown on quadrangle maps S-A-3/5 to S-A-3/36, inclusive, in this appendix. Drilling and seismic explorations for quarry sites were made at Mille Roches, Ontario; at Knapps Station, N. Y.; and on the St. Regis Indian Reservation. Details are shown on sheet 135, File S-A-3/1, in the Folio of Subsurface Exploration, Appendix B-1. Map S-A-3/2, Sheet 136, also included in the Folio of Subsurface Exploration, shows test pitting and auger boring in the sand and gravel deposit at Owls Head, N. Y. All of the deposits which showed possibilities of being suitable as sources for concrete aggregate were sampled and tested. Field inspection reports, giving pertinent data regarding each deposit investigated in the United States and in Canada, are in the district files. While only typical examples of the Field Inspection Report forms are given in this appendix, a tabulation of data, S-A-3/37, giving the location, type of material, estimated quantity, and estimated possibility for use as a source of concrete aggregate for each deposit is included.

A copy of a memorandum to G. A. Lindsay, Chairman, Canadian Temporary Great Lakes-St. Lawrence Basin Committee, covering some of the possible sources of concrete aggregate in Canada, by Mr. E. Viens and Miss A. E. Wilson of the Department of Public Works and the Geological Survey, is given in this appendix. The maps originally submitted with this memorandum have been omitted, the information noted thereon has been transferred to the appropriate Canadian Quadrangles in this appendix, and all references have been changed to conform with the pit numbers assigned to these sources.

During the aggregate survey several deposits were found which contained sufficient quantities of favorable appearing material to warrant detailed investigations. Brief summaries of these more important field explorations are given in this appendix.

In the preliminary investigations of concrete aggregate the magnesium sulphate accelerated soundness test was generally employed to give indications of the inherent quality of material. The test results, including magnesium sulphate loss, specific gravity, gradation, absorption, and other characteristics are shown in tabulations S-A-3/3 and S-A-3/4 in this appendix. In addition to the tests for physical characteristics of the aggregates, special tests were made to determine the relative effects of different coarse and fine aggregate in concrete. These are described under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

PRINCIPAL FINDINGS

The principal findings derived from the concrete aggregate investigation, including field explorations and laboratory studies, are listed below:

(1) The Beckmantown dolomite, Black River limestone, and Lyon Mountain syenite are considered satisfactory for use as coarse aggregate.

(2) It appears unlikely that any natural gravel coarse aggregate can be found, within economic reach of this project, that will meet the standard of quality desired for the major permanent construction.

(3) Crushed dolomite and crushed syenite fine aggregate are considered satisfactory for use in concrete.

(4) The natural sands found in beaches and bars within a 50 mile radius of the project contain considerable deleterious material. It was not proved that these sands are not satisfactory and additional test will be required before final decision can be made regarding their suitability.

(5) Glacial sands from sources such as are located near Lowville, N. Y., and at Joliette, Quebec, were found to be relatively free of deleterious materials.

6. The most favorable sources for concrete aggregare which meet the requirements of current specifications are summarized in the table below:

Type of Material	Location	Approximate Quantity of Mat'l Available	Transportation Available
Dolomite*	2 miles N. of Norwood, N.Y., Pit #8	Unlimited	15 m. by N.Y.C. RR to Massena, N.Y.
Dolomite*	Near Knapp Station, N.Y., Pit#30	Unlimited	10 m. by NYCRR to Massena
Dolomite*	In village of Ogdensburg, N.Y., Pit #904	Unlimited	57 m. by NYCRR to Massena Approx.45 m. by barge
Dolomite*	1½m. N.W. of Helena, N.Y., Pit #108	Unlimited	10 m. by Grand Trunk R.R. to Massena, 6 m. by NYCRR to Cornwall Junction, Canada
Dolomite*	Point Rockway Canal Site, Pit #805	Sufficient for Projects in vic. of Pt.Rockway,NY	At Site
Lime stone**	1 m. N. of Mille Roches, Prov. Ontario, Canada	Unlimited	5 m. by Canadian National RR to Cornwall Junction
Natural Sand	10 m. N.E. Joliette Prov. Quebec, Canada	Unlimited	125 m. by Canadian Nat'l RR to Cornwall, Ont., Canada
Natural Sand and Gravel	In village of Owls Head, N. Y., Pit #1501	4,000,000 Cu.Yds. of sand 2,000,000 Cu.Yds. of gravel	61 m. by NYCRR and Rutland R.R. To Massena

Natural Sand	1½ m. S. of Croghan, N.Y., Pit #5201	Unlimited	102 m. by N.Y.C.R.R. to Massena
Natural Sand	1½ m. S. of Boonville, N.Y., Pit #7700	Unlimited	125 m. by N.Y.C.R.R. to Massena

* Source for both fine and coarse crushed aggregate.
**Source for coarse aggregate only.

7. Other concrete aggregate sources of possible merit are shown in the following table. Investigations of these deposits were not completed for various reasons such as the variable nature of the deposit, the geographic location and accessibility, and the similarity of the material to other materials which had been included in special studies. Future developments influencing any of these factors might cause further consideration and subsequent detailed investigation.

Type of Material	Location	Approximate Quantity of Mat'l Available	Transportation Available
Dolomite	Railroad quarry in Prescott, Ontario, Canada	Unlimited	44 m. by Canadian Nat'l R.R.to Cornwall Junction, Canada
Dolomite	Windmill Point, Ontario, Canada	Unlimited	44 m. by Canadian Nat'l R.R. to Cornwall Junction, Canada
Lime Stone	3 m. N. of Cornwall, Ontario, Canada	Unlimited	No railroad facilities
Natural Sand	8 m. N.E. of Oka, P.Q., Canada	1,000,000 Tons	Approx. 70 m. by barge to Cornwall, Canada
Natural Sand	Near village of St.Felix de Valois, P.Q., Canada	Unknown but probably large	Approx. 135 m.
Iron Ore Tailings	In village of Lyon Mt., N.Y., Pit #1600	20,000,000 tons of fine aggregate. ½ million tons of coarse aggregate	85 m. by Delaware & Hudson, N.Y.C. and Rutland R.R. to Massena
Natural Sand	3/4 m. W. of village of Santa Clara, N.Y., Pit #1401	Sufficient fine aggregate for the St. Lawrence Riv. Project	36 m. by highway to Massena. No railroad facilities.
Natural Sand	1 m. S.W. village of Brier Hill, N.Y., Pit #900	500,000 Cu.Yds.	74 m. by N.Y.C.R.R. to Massena or 35 m. by barge to Point Rockway.

8. The fact that only 18 aggregate sources were listed in the tables, paragraph (6) and (7), does not imply that other sources should be excluded. Materials from sources not listed in these tables should be considered and tested when submitted for approval.

REGIONAL GEOLOGY

The St. Lawrence valley between the Thousand Islands and Montreal is a plain of low relief lying between the Pre-Cambrian highlands of the Adirondacks in New York and the Laurentians in Canada. The entire region has been considerably modified by glaciation. During the advance of the last glacier, the bedrock was blanketed by a very irregular deposit of glacial till composed of compact, variable, unstratified, clayey to silty, gravelly sand with boulders. When the glacier began to melt from the Adirondack and the Ontario basin, the St. Lawrence valley was blocked by ice so that a lake known as Lake Iroquois was impounded behind the ice dam. One of the main outlets for this lake was at Rome, N. Y. A later outlet at a lower elevation was at Covey Hill, Quebec. Rivers flowing off the Adirondack Highland built great deltas along the shore of the glacial lake. Remnants of these deltas are now found along the borders of the old lake in the vicinity of Malone, Parishville, Lowville and Boonville, N. Y. Most of the deltas are composed of detritus from the crystalline rocks of the Adirondacks and in general consist of hard, sound, unweathered sand and gravel. As the ice continued to melt northward, the St. Lawrence valley was uncovered, and Lake Iroquois drained away. Since the land was depressed below sea level by the weight of the ice, marine waters advanced into the valley to form the Champlain Sea. Because of ice-front conditions during the withdrawal of the glacier, aqueo-glacial deposits are rare in the St. Lawrence valley. Some aqueo-glacial deposits composed, like the deltas, of hard, crystalline rock aggregates, were laid down in the Adirondack Highland. Aqueo-glacial sands and gravels were also deposited in Canada in regions and adjacent to or on the Pre-Cambrian crystalline rocks.

In the St. Lawrence valley which was flooded by the Champlain Sea, fine sand and clay were deposited. The higher hills and ridges of glacial till appeared as islands in this inland sea, and continued wave and current action on the exposed till hills resulted in the development of beaches and bars on the slopes. The land rose and the sea was forced out of the valley, leaving low, beached till hills in a region of wide clay and sand-filled valleys. The material in the till hills was derived largely from the underlying and adjacent Paleozoic rocks. Many of these sedimentary rocks consist of shale, sandstone, and some dolomites which weather rapidly.

The bedrock in the St. Lawrence valley is a series of flat-lying, Paleozoic, sedimentary rocks overlying the Pre-Cambrian crystalline rocks like those exposed in the Adirondacks and the Laurentians. The bedrock at the rock surface in the vicinity of the St. Lawrence river from Ogdensburg, N. Y. to Valleyfield, Quebec, consists of the Ordovician Beekmantown and Chazy formations. The Beekmantown formation on both sides of the river from Ogdensburg to Ogden Island consists chiefly of dolomite with thin strata of limestone, sandstone, and shale. The Chazy overlies the Beekmantown and is composed of limestone, dolomite, shale, and sandstone. The chazy extends from Ogden Island to the lower end of Barnhart Island, where the Beekmantown again occurs on both sides of the river to Valleyfield, Quebec. North of the river are the successively high Black River and Trenton formations. The Black River formation, exposed in the Mille Roches quarry north of Mille Roches, Ont., is mainly limestone. The Trenton formation exposed farther north consists of dolomite, limestone, and shale. South of the river are the lower formations, the Buck's Bridges mixed beds and the Cambrian Potsdam sandstone which outcrops in the vicinity of Potsdam, N. Y.

DATA FROM FIELD INSPECTION REPORTS

Pit No.	U.S.G.S. Quadrangle	S-A File, No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Massena R.R.	Miles from Massena Hwy.	Estimated Possibility for use as a source of Concrete Aggregate
1	Massena	3/5	Whitaker	S. & G.	40/60	100,000	20	8	Not recommended
2	"	"	N. Quarries	"	---	100,000+	14	13	Slight possibility
3	"	"	N. & S.L. R.R.	"	60/40	20,000	18	13	Not recommended
4	"	"	----	"	---	5,000	6	4	" "
5	"	"	----	"	---	10,000	--	5	" "
6	"	"	----	"	70/30	10,000	23	14	" "
7	"	"	Fletcher	"	40/60	200,000	18	12	" "
8	"	"	N. Quarries	Dolomite	---	Unlimited	15	13	Recommended
9	"	"	Premo	S. & G.	40/60	150,000	--	5	Slight possibility
10	"	"	Aluminum Co.	"	30/70	10,000	--	3	Not recommended
11	"	"	Hartford	"	35/65	80,000	--	5	" "
12	"	"	Manning	"	50/50	10,000	--	2	" "
13	"	"	----	"	---	20,000	--	6	" "
14	"	"	Sullivan	"	40/60	80,000	--	9	" "
15	"	"	Andrew Bros.	"	40/60	30,000	22	11	" "
16	"	"	Mahoney	"	30/70	80,000	11	14	" "
17	"	"	Walker	"	30/70	20,000	8	9	" "
18	"	"	Oaks	"	35/65	80,000	6	7	" "
19	"	"	Farnsworth	"	50/50	10,000	4	6	" "
20	"	"	Labarge	"	40/60	50,000	4	3	" "
21	"	"	Baxter	"	60/40	20,000	--	4	" "
22	"	"	Wilson	"	30/70	40,000	--	6	" "
23	"	"	Tyo	"	30/70	100,000	--	6	Slight possibility
24	"	"	Munson	"	35/65	15,000	21	12	Not recommended
25	"	"	Munson	"	35/65	10,000	21	12	" "

Pit No.	U.S.G.S. Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S. ratio	Estimated Quantity Cu. Yds.	Miles from Massena R.R.	Hwy.	Estimated Possibility for use as a source of Concrete Aggregate
26	Massena	3/5	Baxter	S. & G.	45/55	5,000	4	4	Not recommended
27	"	"	---	"	60/40	10,000	--	10	" "
28	"	"	Badie	"	60/40	10,000	--	6	" "
29	"	"	Alexandria	"	50/50	25,000	--	7	" "
30	"	"	Cseledi	Dolomite	---	Unlimited	8	10	Recommended
100	Moria	3/6	---	S. & G.	5/95	---	10	12	Not recommended
101	"	"	---	"	40/60	10,000	--	14	" "
102	"	"	---	"	---	10,000	--	14	" "
103	"	"	---	"	40/60	10,000	35	20	" "
104	"	"	---	Sand	---	---	18	17	" "
105	"	"	Potter	S. & G.	60/40	10,000	14	14	" "
106	"	"	---	"	55/45	10,000	11	11	" "
107	"	"	---	"	60/40	---	18	18	" "
108	"	"	Helena	Dolomite	---	Unlimited	11	10	Recommended
200	Malone	3/7	Langlois	Sand	---	100,000 +	--	30	Not recommended
202	"	"	Paro	S. & G.	60/40	1,000,000	53	40	" "
203	"	"	Hutchin	"	---	10,000	50	35	" "
204	"	"	Fallon	"	---	10,000	50	35	" "
205	"	"	---	"	---	10,000	50	35	" "
206	"	"	Tuttle	"	---	100,000	--	30	" "
207	"	"	Porter	"	10/90	100,000	52	40	" "
701	Waddington	3/8	Shinn	"	60/40	10,000	--	11	" "
707	"	"	Haggett	"	50/50	500,000	17	14	Investigate further (1)
802	Red Mills	3/9	Hunter	"	50/50	50,000	--	23	Investigate further(1)
803	"	"	Morrison	"	---	50,000	--	25	Investigate further (1)
804	"	"	Hanna	"	---	50,000	--	27	Investigate further (1)
805	"	"	Vincent	"	---	10,000	--	27	Not recommended

(1) The quantity of material available should be determined by drilling and test pitting.

Pit No.	U.S.G.S. Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S Ratio	Estimated Quantity Cu. Yds.	Miles from Massena R.R.	Miles from Massena Hwy.	Estimated possibility for use as a source of Concrete Aggregate
900	Brier Hill	3/10	Gray	S. & G.	30/70	500,000 +	*	--	Investigate further (1)
901	" "	"	Lowrey	"	---	10,000	75	--	Not recommended
902	" "	"	Watson	"	---	20,000	**	--	Investigate further (1)
903	" "	"	Jefferson Co.	"	50/50	20,000	77	--	Not recommended
904	" "	"	McConville	Dolomite	---	Unlimited	38	--	Recommended
1000	Ogdensburg	3/11	Beamish	S. & G.	---	100,000	33	30	Investigate further (1)
1001	"	"	White	"	---	50,000	33	30	" "
1002	"	"	Tuck	"	50/50	10,000	37	30	" "
1006	"	"	Earles	Sand	---	100,000	40	35	" " (1)
1103	Canton	3/12	Bowker	S. & G.	40/60	30,000	18	18	Not recommended
1104	"	"	Orvis-McLear	"	---	----	23	25	" "
1200	Potsdam	3/13	----	Sand	---	Unlimited	--	22	Not recommended
1201	"	"	----	"	---	"	--	18	" "
1202	"	"	----	"	---	"	--	22	" "
1203	"	"	Barton Brook	S. & G.	---	"	--	22	" "
1209	"	"	----	"	50/50	500,000	24	23	Slight possibility
1212	"	"	Bicknell	"	30/70	500,000	24	23	" "
1213	"	"	Benson	"	10/90	1,000,000	24	23	" "
1214	"	"	Brown	Sand	---	50,000	31	19	Investigate further
1300	Nichclville	3/14	Franklin Co.	"	---	30,000	--	35	Not recommended
1302	"	"	----	S. & G.	50/50	15,000	--	35	" "
1305	"	"	Clookey	Sand	---	600,000	--	38	Investigate further
1401	Santa Clara(2)		S.C.Sand Co.	S. & G.	30/70	1,000,000	59	35	" "
1501	Loon Lake (2)		Owls Head	"	30/70	6,000,000	59	50	Good possibility

* 3 miles to St. Lawrence River + 29 miles by barge to Pt.Rockway
(1) The quantity of material available should be determined by test pitting, and augering.
** 3/4 miles to St.Lawrence River + 29 miles by barge to Pt.Rockway
(2) U.S.G.S. Quadrangle map retained in district file No.________.

S-A-3/37

Pit No.	U.S.G.S. Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S Ratio	Estimated Quantity Cu. Yds.	Miles from Massena R.R.	Miles from Massena Hwy.	Estimated possibility for use as a source of Concrete Aggregate
1600	Lyon Mt.	(2)	Lyon Mt.	Iron Ore Tailings	---	20,000,000 T.	85	85	Good possibility
2600	Russell	(2)	Given	S. & G.	---	20,000	69	--	Not recommended
2601	"	(2)	---	"	50/50	50,000	72	--	" "
2602	"	(2)	---	"	10/90	100,000	72	--	Slight possibility
5200	Lowville	3/15	Allen	S. & G.	5/95	500,000	103	--	Recommended
5201	"	"	---	"	5/95	--------*	105	--	"
5202	"	"	---	"	5/95	500,000	107	--	"
5203	"	"	---	"	40/60	--------*	105	--	"
5204	"	"	---	"	5/95	500,000	106	--	"
5205	"	"	---	"	5/95	--------*	105	--	"
5400	Watertown	(2)	Collwell	S.& G.	15/85	2,000,000	90	96	Slight possibility
5401	"	"	Vesta	Sand	---	500,000	90	96	" "
5700	Pulaski	(2)	Lacona	"	---	1,000,000	114	--	Not recommended
6000	Port Leyden	3/16	Hamblen	S. & G.	90/10	---	118	--	" "
6001	" "	"	---	"	5/95	Unlimited	111	--	Good possibility
6002	" "	"	---	"	10/90	"	119	--	" "
6003	" "	"	---	"	10/90	500,000	118	--	" "
6004	" "	"	---	"	10/90	Unlimited	113	--	" "
6005	" "	"	---	"	10/90	"	119	--	" "
7600	Remsen	(2)	Forestport	Sand	---	-----	150	--	Not recommended
7700	Boonville	(2)	Boonville	"	---	3,000,000	125	--	Recommended

* Deposit represented by pit Nos. 5201, 5203, and 5205 contains over 3,000,000 cu.yds.
(2) U.S.G.S. Quadrangle map retained in district file No.______.

S-A-3/37

 DATA FROM FIELD INSPECTION REPORTS

Pit No.	Canadian Quadrangle	S.A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S Ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Miles from Cornwall Jct. Hwy.	Estimated possibility for use as a source of Concrete Aggregate
1	Cornwall	3/17	Glen Gordon	S. & G.	35/65	8,000	14	17	Not recommended
2	"	"	St. Raphael	"	35/65	10,000	17	20	" "
3	"	"	----	"	40/60	10,000	17	22	" "
4	"	3/17	Martintown	"	---	---	13	14	" "
5	"	"	----	"	40/60	5,000	--	1½	" "
6	"	"	----	"	----	10,000	6	7	Not recommended
7	"	"	----	"	----	10,000	5	6	" "
8	"	"	Murphy	"	40/60	10,000	10	10	" "
9	"	"	Black River	"	40/60	10,000	10	10	" "
10	"	"	Harrison Corners	"	50/50	10,000	10	10	" "
11	"	"	-----	"	80/20	---	10	11	Not recommended
12	"	"	Northfield Sta.	"	70/30	150,000	13	14	" "
13	"	"	Dixon	"	---	----	14	16	" "
14	"	"	----	"	80/20	---	13	14	" "
15	"	"	Coleman	"	50/50	10,000	--	9	" "
16	"	"	Stewart	"	35/65	10,000	32	16	Not recommended
17	"	"	----	"	---	----	12	14	" "
M.R.	"	"	Mille Roches	Limestone	---	Unlimited	5	5	Recommended
100	Morrisburg	3/18	Bouckhill	S. & C.	40/60	8,000	32	28	Not recommended
101	"	"	Williamsburg	"	35/65	8,000	31	28	" "
102	"	"	-------	"	60/40	2,000	32	29	" "
103	"	"	Glen Beckar	"	40/60	5,000	30	29	" "
104	"	"	Cardinal	"	35/65	10,000	37	---	" "

S-A-3/37

S-A-3/37

Pit No.	Canadian Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Miles from Cornwall Jct. Hwy	Estimated possibility for use as a source of Concrete Aggregate
105	Morrisburg	3/18	------	S. & G.	35/65	10,000	38	--	Not recommended
106	"	"	------	"	40/60	18,000	44	--	" "
107	"	"	------	Dolomite	---	Unlimited	46	--	Further investigation
200	Winchester	3/19	Blair	S. & G.	50/50	500,000	27	23	Not recommended
201	"	"	Berwick	"	15/85	10,000	22	24	" "
202	"	"	Lachapelle	"	---	200,000	21	25	" "
203	"	"	----	"	35/65	8,000	21	23	" "
204	"	"	----	"	20/80	8,000	18	20	" "
205	Winchester	"	-----	S. & G.	---	2,000	18	20	Not recommended
206	"	"	-----	"	50/50	6,000	28	30	" "
207	"	"	-----	"	50/50	8,000	28	30	" "
208	"	"	-----	"	60/40	10,000	34	35	" "
209	"	"	-----	"	---	10,000	31	35	" "
300	Merrickville	3/20	Black	"	60/40	250,000	53	--	Not recommended
301	"	"	-----	"	60/40	5,000	57	--	" "
302	"	"	Oxford Sta.	"	40/60	8,000	60	--	" "
303	"	"	-----	"	50/50	10,000	55	--	" "
304	"	"	-----	"	20/80	8,000	56	--	" "
305	Merrickville	3/20	-----	S. & G.	30/70	8,000	56	--	Not recommended
306	"	"	-----	"	50/50	10,000	62	--	" "
307	"	"	Kyle	"	35/65	100,000	53	55	" "
308	"	"	------	"	20/80	10,000	53	--	" "
400	Kemptville	3/21	------	S. & G.	40/60	30,000	49	55	Slight possibility
401	"	"	------	"	"	35,000	49	55	" "
402	"	"	Reid Mills	"	50/50	20,000	62	--	Not recommended
403	"	"	Nixon	"	40/60	50,000	60	--	" "
404	"	"	-------	"	---	10,000	67	--	" "

Pit No.	Canadian Quadrangle	S-A File No	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Miles from Cornwall Jct. hwy.	Estimated possibility for use as a source of Concrete Aggregate
405)	Kemptville	3/21							
406)	"	"	Richmond	S. & G.	25/75	4,000,000	74	--	Investigate Further
407)	"	"							
408	"	"	Munster	"	---	10,000	78	--	Not recommended
409	"	"	C.P. R.R.	"	---	15,000	45	35	" "
410	Kemptville	3/21	----	S. & G.	---	10,000	48	--	Not reco mmended
411	"	"	----	"	---	25,000	50	--	Slight possibility
412	"	"	----	"	---	25,000	50	--	" "
500	Ottawa	3/22	Foster	S.& G.	25/75	250,000	61	--	Slight possibility
501	"	"	--	Sand	---	10,000	66	--	Not recommended
502	"	"	--	Sand	---	--	63	--	" "
503	"	"	Foster	Sand	---	30,000	63	--	" "
504	"	"	--	S & G	40/60	50,000	63	--	" "
505	Ottawa	3/22	Spratt	S.&G.	50/50	1,000,000 +	61	--	Not recommended
506	"	"	---	"	---	10,000	68	--	" "
507	"	"	---	"	---	10,000	68	--	" "
600	Arnprior	---	---	S. & G.	10/90	150,000	96	--	Slight possibility
601	"	---	---	"	---	10,000	102	--	Not recommended
602	"	---	---	"	---	10,000	102	--	" "
603	"	---	---	"	---	30,000	97	--	" "
604	"	---	---	"	---	8,000	97	--	" "
700	Carleton Place	3/23	---	S.& G.	15/85	2,000,000	100	--	Slight possibility
800	Huntingdon	3/24	Grand Trunk R.R.	S. & G.	40/60	30,000	24	24	Not recommended
801	"	"	Houle	S.& G.	50/50	30,000	24	24	Not recommended
802	"	"	Currie	"	30/70	100,000	25	25	" "
803	"	"	Taillon	"	10/90	50,000	25	26	" "

Pit No.	Canadian Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Miles from Cornwall Jct. Hwy.	Estimated possibility for use as a source of Concrete Aggregate
900	Russell	3/25	Leonard	S.& G.	---	500,000	77	--	Slight possibility
901	"	"	Navan	"	---	50,000+	73	--	" "
902	"	"	---	"	---	20,000	72	--	Not recommended
903	"	"	---	"	---	20,000	70	--	" "
904	"	"	Vars	"	---	50,000	46	--	" "
1300	Renfrew	3/26	C.N. R.R.	S. & G.	70/30	1,000,000	135	--	Not recommended
1400	Sharbot Lake	3/27	Gibson	Sand	--	1,000,000	125	--	Slight possibility
1401	" "	"	Jardine	S. & G.	35/65	100,000+	125	--	Slight possibility
2001	Mallory Town	3/28	Dufferin	S. & G.	30/70	1,000,000+	60 by water		Investigate further
2002	" "	"	Poole	"	30/70	1,000,000+	" " "		Investigate further
2003	" "	"	Simpson	"	30/70	1,000,000 +	" " "		Investigate further
--	--------	---	Oka	Sand	---	1,000,000+	55	---	Slight possibility
--	--------	---	Joliette	S. & G.	10/90	3,000,000 +	131	--	Recommended
--	Brockville	---	C.N. R.R.	Dolomite	---	Unlimited	44	--	Investigate further
--	"	---	Windmill Pt.	"	---	"	44	--	Investigate further
--	--------	---	St. Felix	Sand	---	--------	135	---	Investigate further

S-A-3/37

Pit No.	Canadian Quadrangle	S-A File No	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Miles from Cornwall Jct. hwy.	Estimated possibility for use as a source of Concrete Aggregate
405)	Kemptville	3/21							
406)	"	"	Richmond	S. & G.	25/75	4,000,000	74	--	Investigate Further
407)	"	"							
408	"	"	Munster	"	---	10,000	78	--	Not recommended
409	"	"	C.P. R.R.	"	---	15,000	45	35	" "
410	Kemptville	3/21	----	S. & G.	---	10,000	48	--	Not reco mmended
411	"	"	----	"	---	25,000	50	--	Slight possibility
412	"	"	----	"	---	25,000	50	--	" "
500	Ottawa	3/22	Foster	S.& G.	25/75	250,000	61	--	Slight possibility
501	"	"	--	Sand	---	10,000	66	--	Not recommended
502	"	"	--	Sand	---	--	63	--	" "
503	"	"	Foster	Sand	---	30,000	63	--	" "
504	"	"	--	S & G	40/60	50,000	63	--	" "
505	Ottawa	3/22	Spratt	S.&G.	50/50	1,000,000 +	61	--	Not recommended
506	"	"	---	"	---	10,000	68	--	" "
507	"	"	---	"	---	10,000	68	--	" "
600	Arnprior	---	---	S. & G.	10/90	150,000	96	--	Slight possibility
601	"	---	---	"	---	10,000	102	--	Not recommended
602	"	---	---	"	---	10,000	102	--	" "
603	"	---	---	"	---	30,000	97	--	" "
604	"	---	---	"	---	8,000	97	--	" "
700	Carleton Place	3/23	---	S.& G.	15/85	2,000,000	100	--	Slight possibility
800	Huntingdon	3/24	Grand Trunk R.R.	S. & G.	40/60	30,000	24	24	Not recommended
801	"	"	Houle	S.& G.	50/50	30,000	24	24	Not recommended
802	"	"	Currie	"	30/70	100,000	25	25	" "
803	"	"	Taillon	"	10/90	50,000	25	26	" "

S-A-3/37

Pit No.	Canadian Quadrangle	S-A File No.	Local Name of Pit or Quarry	Sand, Gravel or Stone	Est. G/S ratio	Estimated Quantity Cu. Yds.	Miles from Cornwall Jct. R.R.	Hwy.	Estimated possibility for use as a source of Concrete Aggregate
900	Russell	3/25	Leonard	S.& G.	---	500,000	77	--	Slight possibility
901	"	"	Navan	"	---	50,000+	73	--	" "
902	"	"	---	"	---	20,000	72	--	Not recommended
903	"	"	---	"	---	20,000	70	--	" "
904	"	"	Vars	"	---	50,000	46	--	" "
1300	Renfrew	3/26	C.N. R.R.	S. & G.	70/30	1,000,000	135	--	Not recommended
1400	Sharbot Lake	3/27	Gibson	Sand	--	1,000,000	125	--	Slight possibility
1401	" "	"	Jardine	S. & G.	35/65	100,000+	125	--	Slight possibility
2001	Mallory Town	3/28	Dufferin	S. & G.	30/70	1,000,000+	60 by	water	Investigate further
2002	" "	"	Poole	"	30/70	1,000,000+	" "	"	Investigate further
2003	" "	"	Simpson	"	30/70	1,000,000 +	" "	"	Investigate further
--	--------	---	Oka	Sand	---	1,000,000+	55	---	Slight possibility
--	--------	---	Joliette	S. & G.	10/90	3,000,000 +	131	--	Recommended
--	Brockville	---	C.N. R.R.	Dolomite	---	Unlimited	44	--	Investigate further
--	"	---	Windmill Pt.	"	---	"	44	--	Investigate further
--	--------	---	St. Felix	Sand	---	--------	135	---	Investigate further

S-A-3/37

EXPLORATION AND SAMPLING OF AGGREGATE SOURCES IN NORTHERN NEW YORK

During the aggregate survey of the Northern New York region, several deposits were found which contained sufficient material to warrent more detailed investigation than was made of the many deposits listed in the tabulation of data from field inspection reports in this appendix. A brief resume of the field exploration of these deposits is given below:

1. Point Rockway Canal Cut (Beekmantown dolomite).

(a) Location - This deposit is located on the site of the proposed Point Rockway Canal, Point Rockway, New York (Pit #801, may S-A-3/9 in this appendix.)

(b) Geology - The bedrock in the vicinity of Point Rockway of the New York mainland is part of the Beekmantown formation which is lower Ordovician in age. The beds at the rock surface in the vicinity of Point Rockway probably are among the highest beds of the Beekmantown section. The rock is dark gray dolomite with thin beds and stringers of shale. The rock is almost horizontally bedded and is cut by several systems of joints. While some weathering has occured along bedding planes and joints in the upper 5 feet of rock, below this depth the rock is generally unweathered.

(c) Quantity represented - There is a sufficient quantity of dolomite stone to be removed from the canal cut to supply aggregate for the Iroquois Dam and the Point Rockway Canal. The canal excavation is divided between the Iroquis Dam and the Point Rockway Canal contractors so that each project will receive all of the stone necessary for concrete aggregate requirements.

(d) Laboratory tests - Stone cores taken from foundation drilling were used in making quality tests for concrete aggregate. Samples of these cores were sent to the Central Concrete Laboratory, West Point, N. Y. for petrographic analysis and freezing and thawing soundness tests. The petrographic study indicated that this rock contained a slightly higher percentage of argillaceous material than was found in the Knapps Station dolomite, Pit No. 30. The results of 18 cycles of freezing and thawing tests at West Point indicated no appreciable deterioration. The results of 34 cycles of freezing and thawing on 96 core samples from the same vicinity, tested at Massena, further substantiated the soundness of this material. The description of these tests and photographs showing appearance of cores before and after freezing are in the district files.

(e) Recommedations - This dolomite rock is entirely satisfactory for use in concrete.

2. Northern Quarries Dolomite, Norwood, New York (Beekmantown Formation).

(a) Location - This deposit (Pit #8), owned by Northern Quarries, Incorporated, Norwood, New York, is located on the east bank of the Raquette River on the Norwood and St. Lawrence Railroad, 2 miles north of Norwood, New York, and 11 miles from Massena. At the timeofthe inspection a complete crushing and screening plant was operating in this quarry, supplying crushed stone coarse aggregate for state, county, and private concrete construction. The location of this deposit is shown on map S-A-3/5 in this appendix.

(b) Transportation facilities - Railroad transportation from this deposit to Massena would be as follows: quarry to Norwood, N. Y., Norwood and St. Lawrence Railroad, 2 miles; Norwood to Massena, N. Y. Central R.R., 13 miles: total, 15 miles.

(c) Geology - The bedrock exposed in the town of Norfolk, New York, and at the quarry of Northern Quarries, Inc., is a part of the Beekmantown formation. The beds at the rock surface in this area are in the lower portion of the Beekmantown formation. The rock is horizontally bedded dolomite with occasional thin stringers of shale. Slight weathering has occured along bedding

planes and joints in the upper 5 feet of the rock, but below this zone the rock is generally unweathered.

(d) Quantity represented - It is estimated that there is a sufficient quantity of dolomite stone in this deposit to furnish fine and coarse aggregate for the St. Lawrence River Project.

(e) Method of sampling - Over 8 tons of crushed store above the ¼ inch were taken from stock piles at the quarry and shipped to the Central Concrete Labratory, West Point, N. Y. In addition, several tons of hammermill-crushed fine aggregate were prepared at the quarry and sent to the laboratory for testing in conjunction with other aggregates. In order to determine the particle shape and gradation that might be expected from crushing, samples of the coarse aggregate were shipped to the following companies for crushing:

Gruendler Crusher and Pulverizer Co., St. Louis, Missouri,
American Pulverizer Co., St. Louis, Missouri,
Pennsylvania Crusher Co., Philadelphia, Pennsylvania,
Nordberg Manufacturing Co., Milwaukee, Wisconsin.

It was found that with proper equipment and crushing methods, satisfactory grading and particle shape of fine aggregate could be obtained.

(f) Laboratory tests - The results of the routine tests made on crushed fine and coarse aggregate from this quarry are shown in Tables S-A-3/3 and S-A-3/4, and the results of special tests on these materials are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(g) Recommendations - The dolomite rock from this deposit is considered satisfactory for use as concrete aggregate.

3. Knapps Station Dolomite, Knapps Station, New York. (Beekmantown formation.)

(a) Location - This deposit (Pit 30), owned by Northern Quarries, Incorporated, Norwood, and other owners, is located 2 miles east of East Norfolk, on the New York Central Railroad, 7 to 10 miles south of Massena. The deposit extends north and south, roughly paralleling the N.Y.C. R.R. for a distance of approximately 3 miles. The depth of overburden ranges from 1 to 3 feet in the southern section (owned by Northern Quarries) to a depth of 36 feet in the northern end of the deposit. A small quarry (the Hale quarry) is located on the Steve Cseledi farm owned by Northern Quarries. Approximately 1200 cubic yards of dolomite stone were removed from this quarry several years ago for use as flagstones and other masonry work in Massena. A detail map (S-A-3/1, Sheet 135, Folio of Subsurface Exploration, Appendix R-1) shows the depth of overburden, the spacing of seismic shots, and the log of the drill hole made in the lower end of the deposit. This deposit is also shown on map S-A-3/5 in this appendix.

(b) Transportation facilities - Rail shipment from this deposit to Massena, a distance of approximately 8 miles, would be via the New York Central Railroad.

(c) Geology - The bedrock exposed in the town of Norfolk, N. Y., at the quarry of Northern Quarries, Inc., and at outcrops and the small quarry in the vicinity of Knapps Station is part of the Beekmantown formation. Fossils from the Knapps Station locality have been identified as characteristic Beekmantown forms. The rock is horizontally bedded dolomite with occasional thin stringers of shale.

(d) Quantity represented - It is estimated that there is a sufficient quantity of dolomite stone in this area to furnish fine and coarse aggregate for the St. Lawrence River Project.

(e) Method of Sampling - Small representative samples of dolomite stone were obtained by blasting segments of rock from the exposed face of the

Hale quarry. These samples were submitted to the Central Concrete Laboratory, West Point, N. Y., for petrographic analysis and for comparison with dolomite stone from the Northern Quarries deposit. Cores from drill hole D-1111 were also submitted to the laboratory for petrographic analysis.

(f) Laboratory tests - The results of petrographic analyses on this material indicate it be very similar to the Northern Quarries dolomite, pit #8, which proved to be satisfactory for use in concrete.

(g) Recommendations - The dolomite rock from this deposit is entirely satisfactory for use as concrete aggregate.

4. St. Regis Dolomite, St. Regis, New York (Beekmantown Formation).

(a) This deposit is located ¼ mile south of the U. S. Canadian boundary line, 1 mile north of Hogansburg, and 7 miles east of the foot of Barnhart Island. The area lies within the boundary of the St. Regis Indian Reservation. There is a small quarry in this deposit, approximately 3/4 miles north of Hogansburg. A detail map (S-A-3/1, sheet 135, Folio of Subsurface Exploration, Appendix B-1) shows the depth of overburden and the spacing of seismic shots which were made in this area. The deposit is also shown on map S-A-3/6 in this appendix.

(b) Transportation facilities - This material could be shipped by barge on the St. Lawrence River from the deposit to the Powerhouse site. Rail haul would require construction of 6 miles of track to Helena. The distance from Helena to Massena Springs via the Grand Truck Railroad is 8.6 miles.

(c) Geology - The rock exposed in small quarries and outcrops on the St. Regis Indian Reservation near the St. Lawrence River belong to the Beekmantown formation. The beds which are exposed probably are the higher beds of the formation. The rock is nearly horizontally bedded dolomite with thin stringers of shale.

(d) Quantity represented - It was estimated that there is a sufficient quantity of dolomite in this deposit to supply all of the fine and coarse aggregate for the St. Lawrence River Project. Two seismic lines were run on this deposit to determine the depth of overburden. From the results of the seismographic investigation, it was determined that the depth of overburden varies from 6 to 35 feet, with the majority of the area covered with overburden to a depth in excess of 20 feet.

(e) Recommendation - Although stone in this deposit appeared similar in quality to the dolomite in the Northern Quarries deposit, this should be confirmed by laboratory tests.

5. Helena Dolomite Deposit, Helena, New York (Beekmantown formation).

(a) Location - This deposit is located approximately 1½ miles northwest of Helena on the New York Central Railroad, on the Ross Segar, Henry McIntyre and Lantry farms. The deposit, pit #108, is shown on map S-A-3/6 in this appendix. Two small quarries, on the Segar and McIntyre farms, respectively, were noted. Quarry stone from this deposit was used in the construction of masonry bridge piers in Helena.

(b) Transportation facilities - Rail transportation to Massena would be as follows: New York Central Railroad to Helena, 1 mile; Grand Trunk Railroad, Helena to Massena, 9 miles; total, 10 miles. The distance to Cornwall Junction via the New York Central Railroad is approximately six miles.

(c) Geology - The rock exposed in small quarries in this vicinity also belongs to the Beekmantown formation. It appeared, in every respect, to be the same type and quality of stone as that found in the Northern Quarries deposit. There is a sufficient area with less than 20 feet of overburden in

this vicinity to furnish fine and coarse aggregate for the St. Lawrence River Project.

(d) Recommendations - The location of this deposit and the railroad facilities are favorable and it is believed that this would be an excellent source for concrete aggregate.

6. Ogdensburg Dolomite Deposit, Ogdensburg, New York (Beekmantown formation)

(a) Location - This exposure of bedrock (Pit 904) is located in the southwest part of Ogdensburg, 1 mile southwest of the mouth of the Oswegatchie River, and 1/8 mile southeast of the St. Lawrence River. The deposit is located on the McConville and Ellis' properties. At the time of the inspection, a small crushing and screening plant was in operation in the McConville quarry. Approximately 100,000 cubic yards of dolomite had been removed from this site, but no material had been removed from the adjacent Ellis property.

(b) Transportation facilities - Rail haul from Ogdensburg to Massena would be as follows: Ogdensburg to DeKalb Junction, N. Y. C. R.R., 19 miles; DeKalb Junction to Massena Springs, N.Y.C. R.R., 38 miles: total, 57 miles. Water transportation would be by barge from Ogdensburg to Barnhart Island, approximately 45 miles.

(c) Geology - The bedrock in the vicinity of Ogdensburg is in the Beekmantown formation. Geologically the rock is the same as the dolomite at Point Rockway, described above.

(d) Quantity represented - It is estimated that there is a sufficient quantity of dolomite rock in the McConville and Ellis deposits to furnish fine and coarse aggregate for the entire project.

(e) Laboratory tests - Small samples of stone from stock piles in the McConville Quarry were sent to the Central Concrete Laboratory, West Point, New York. This material is a fine grained, gray dolomite with a uniform texture. The results of routine tests are shown in Table S-A-3/4 in this appendix.

(f) Recommendations - Material from this deposit is satisfactory for use as fine and coarse aggregate.

7. Iron Ore Tailings, Lyon Mountain, New York.

(a) The stock piles of iron ore tailings investigated are located in the village of Lyon Mountain, approximately 65 miles southeast of Massena. The Republic Steel Corporation operates a large iron ore plant at Lyon Mountain; and the fine and coarse aggregate stock piled around the plant constitute the tailings or be-products of the extraction process. At the time of the inspection it was estimated that there were over 20 million tons of fine aggregate and 500,000 tons of coarse aggregate in these stock piles.

(b) Transportation facilities - Rail haul from Lyon Mountain to Messena would be as follows: Lyon Mountain to Wolf Pond, Delaware and Hudson R.R.; Wolf Pond to Malone, New York Central Railroad; Malone to Norwood, Rutland R.R.; Norwood to Massena, N.Y.C. R.R.: total distance, 85 miles. This rail distance is predicated on the construction of ½ mile of track connecting the Delaware and Hudson and the N. Y. C. R.R. at Wolf Pond.

(c) Geology - Samples of iron ore tailings from mining operations at Lyon Mountain, New York, show that the gangue rock is essentially a syenite consisting of feldspars with minor amounts of quartz. The feldspar is predominantly plagioclase with considerable orthoclase. The ore mineral is magnetite which is disseminated through the syenite. The Lyon Mountain deposit is in the Pre-Cambrian crystalline rock massif of the Adirondack Highland.

(d) Laboratory tests - About 6 tons of this aggregate, from the 3-inch size to sand, were shipped to the Central Concrete Laboratory, West Point, New York for tests. The material was found to be clean, hard, angular, and well

graded. Results of routine laboratory tests are shown in Tables S-A-3/3 and S-A-3/4, and the results of special tests are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(e) Study of structures - Several structures in which Lyon Mountain tailings were used for both fine and coarse aggregate were examined. These included concrete-block houses, stucco houses constructed with fine aggregate tailings, the Lyon Mountain school house, and the concrete highway through Lyon Mountain. These structures varied in age from 8 to 22 years, and in no case was there evidence of any structural failure or staining due to the use of this aggregate.

(f) Recommendations - The laboratory tests indicated this material to be highly resistant to freezing and thawing. The quantity of alkali feldspar identified caused some concern and is being investigated further. Additional tests should be made using this syenite fine aggregate in combination with crushed limestone and crushed dolemite coarse aggregates.

The fact that this aggregate is readily available may justify some special consideration during a period of shortage in labor and production equipment.

8. Owls Head Sand and Gravel Deposit, Owls Head, New York.

(a) Location - The Owls Head Deposit (Pit 1501) is located on the New York Central Railroad in Owls Head, New York, approximately 40 miles southeast of Massena. At the time of this investigation there was a small pit in the approximate center of the deposit. No material has been removed from this pit for several years.

(b) Transportation facilities - Rail shipment from Owls Head to Massena would be as follows: N.Y.C. R.R., Owls Head to Malone, 10.5 miles; Rutland Railroad, Malone to Norwood, 37.5 miles; N.Y.C. R.R., Norwood to Massena, 13 miles; total: 61 miles. If approximately 12 miles of railroad were constructed over the existing road bed from Moira to Helena, a shorter route could be followed: Owls Head to Malone, N.Y.C. R.R.; Malone to Moira, Rutland R.R.; Moira to Helena, N.Y.C. R.R.; Helena to Massena, Grand Trunk; total distance: 46 miles.

(c) Geology - The sand and gravel deposite in this vacinity are the result of aqueo-glacial deposition from an immense mass of ice which occupied the valley of the Salmon River and dammed the valley near Titusville. The material was washed off the ice when the glacier melted and was laid down in roughly stratified and lensed deposits containing material of all sizes. One of the temporary outlets for the lake impounded behind the ice barier was located near the N.Y.C. R.R. tracks northwest of Owls Head, and the material appears to be roughly graded to this outlet, with the coarsest material near the spillway.

(d) Quantity represented - It was estimated that there are approximately 4 million cubic yards of sand and 2 million cubic yards of gravel in this deposit. These figures should be confirmed by additional subsurface exploration, including several deep-sheeted test pits and drill holes.

(e) Method of sampling - A total of 20 test pits, 4 trenches, and 44 auger borings were excavated in this area. A map (S-A-3/2, sheet 136, Folio of Subsurface Exploration, Appendix B-1 shows the location of all excavations and the area lines used for aggregate quantity estimation. On the same sheet are shown the gravel/sand ratio for each pit or trench, the total depth of each hole, the amount of overburden, and details of the "step" method of trench excavation.

After each pit or trench was excavated, samples were taken of each stratum encountered. A sieve analysis, using 4", 2", 1", and ¼" screens, was made

on the material; and after quartering, representative samples were sent to the laboratory.

(f) Appearance of Material - In general, the sand and gravel in this deposit were found to be clean and fairly well graded, with considerable magnetite in some strata. Some disintegrated and rotten stone were evident. Calculated composite samples of the sand from this region showed the average grading of the sand to be a little too fine to meet the specifications. It is believed that this problem could be overcome by crushing a small amount of the coarse aggregate to obtain more material above the No. 16 size, or by wasting some of the finer sizes.

(g) Laboratory tests. - The results of the routine aggregate tests made on this material are shown in Tables S-A-3/3 and S-A-3/4, and the results of special tests are given under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(h) Recommendations - It is believed that the sand and gravel from this deposit can be processed to meet the requirements of the current specifications.

9. The Lowville Sand and Gravel Deposits, Lowville, N. Y.

(a) Location and transportation facilities - Several large sand deposits were located in the vicinity of Lowville, N. Y. The locations and the distances to Massena are given below:

Pit No.	Location of deposit	Rail distance to Massena
5200	½ m. E. of Watson, N. Y.	3 miles to Lowville, + 100 miles N.Y.C. R.R.
5201) 5203) 5205)	Large deposit, approx 7 miles long and ½ m. wide, 1½ m. S. of Crogan, N.Y.; 1 m. E. of New Bremen, N.Y.; and 5 m. E. of Lowville, N. Y.	1 mile to New Bremen, N. Y. + 102 miles N.Y.C. R.R.
5204	1½ miles N. of Crystal Dale, N. Y.	5 miles to New Bremen, N. Y. + 102 miles N.Y.C. R.R.

The location of these deposits are shown on map S-A-3/15 in this appendix.

(b) Present Operations - Mr. Robert Allen, Lowville, New York, operates a small washing and screening plant in Pit #5200. There are no operations in any of the other pits in this vicinity.

(c) Geologh - The sand and gravel on the eastern side of the Black River Valley in the vicinity of Lowville are in delta deposits which were laid down in Lake Iroquois by rivers flowing off the Adirondack Highland. The composition of the aggregates in the deposits show that the material was derived directly from the crystalline rocks of the Adirondacks. In some areas the deposits consist of sand with a large percentage of gravel. In other areas, uniform sand blankets the surface, with the coarser material generally occuring under the uniform sand at depths of 3 to 12 feet. The deposits rest on the extremely irregular surface of Pre-Cambrian rocks.

(d) Quantity represented - An estimate of the quantity of sand in

this region based on field reconnaissance and a few auger holes and test pits is given below.

Pit #	Quantity of Sand represented, Cu. Yds.
5200	500,000
5202	500,000
5201)	
5203)	3,000,000 +
5205)	
5204	500,000

A limited drilling and test-pitting program would be necessary to confirm this estimate.

(e) Method of sampling - Representative samples of the most promising sand deposits were taken by excavating small test pits in the area. In general, sand from these deposits was found to be clean and well graded, with a very small percentage of soft or rotten stone.

(f) Laboratory tests - The results of the routine aggregate tests made on sand from these deposits are shown in Table S-A-3/3 and the results of special tests are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(g) Recommendations - No performance studies of concrete containing sand from this region was made but further investigation should include such observations. Tests have indicated that the sand from these deposits is satiffactory for use in concrete.

10. Santa Clara Sand and Gravel Deposit, Santa Clara, N. Y.

(a) Location - This deposit (Pit 1401), owned by the Santa Clara Sand Company, is located 3/4 miles west of Santa Clara, New York, on the southwest bank of the St. Regis River, approximately 30 miles southeast of Massena. The present pit has not been worked for over 11 years, so that considerable overburden now covers the pit face. The concrete foundations for the original sand processing plant still remain.

(b) Transportation facilities - There is no railroad in the vicinity of this deposit. The distance from Santa Clara to Massena by highway is approximately 36 miles. If 18 miles of track were installed on the existing roadbed of the New York Central Railrlad from Santa Clara to Moira, rail transportation would be as follows: Santa Clara to Moira, 18 miles; Moira to Norwood, 22 miles; Norwood to Massena, 13 miles: total 53 miles.

(c) Geology - The deposit at Santa Clara consists of aqueo-glacial materials which were washed off the last glacier into the valley of the St. Regis River. The deposit is quite extensive and is composed of mineral aggregates derived directly from igneous and metamorphic rocks. The material is roughly stratified and lensed, with beds containing material of all sizes from boulders to fine sand.

(d) Quantity represented - It was estimated that sufficient sand is available in this vicinity to supply the St. Lawrence River Project. This was based on geologic reconnaissance and field observations and should be substantiated by test-pitting and drilling.

(e) Method of sampling - The exposed face of the pit, approximately 40 feet vertically and 75 feet on a slope, was trenched by the "step" method in order to obtain representative samples. The samples were thoroughly mixed, quartered, sieved over a ¼ inch screen, and shipped to the Central Concrete

Laboratory, West Point, N.Y. The coarse aggregate was not tested.

(f) Appearance of material - The sand was found to be clean and fairly well graded, with numerous small veins of magnetite sand. Although the gradation of the composite sample shipped to West Point was too fine to meet Federal Specifications, it was considered probable that further exploration would reveal sufficient coarse sand to satisfy specification requirements. The results of routine laboratory tests made on sand from this area are shown in Table S-A-3/3 in this appendix.

(g) Study of structures - Inspection of a concrete highway bridge near Brushton, N. Y., and of concrete footings for the screening plant mentioned above, did not give any evidence of failure due to unsoundness of the sand.

(h) Recommendations - The lack of railroad facilities in the vicinity of Santa Clara seems to preclude economical delivery of material from this deposit. Also, further exploration and laboratory tests would be required to prove the material.

11. Malone Sand and Gravel Deposit, Malone, New York.

(a) Location - The Malone deposit is located 2 miles southeast of Malone, New York, on the New York Central Railroad, approximately 40 miles by highway and 52 miles by railroad from Massena, New York. There are three pits in this deposit: The Paro pit (Pit #202), the N. Y. C. R.R. pit, and the Nichol pit. At the time of the inspection there was a small washing and screening plant located at the Paro pit. The location of this deposit is shown on map S-A-3/7 in this appendix.

(b) Transportation facilities - Railway would be the most economical means of transporting this material to the sites of construction. Traffic would be over the N.Y.C. R.R. to Malone, 2 miles; the Rutland Railroad to Norwood, N. Y., 37 miles; and the N.Y.C. R.R. to Massena, N.Y., 13 miles ; total, 52 miles.

(c) Geology - During the recession of the last glacier, the drainage in the St. Lawrence River was blocked by ice. The lake impounded behind this ice barrier is known as Glacial Lake Iroquois. At the time when the lake occupied the valley near Malone, which lies in the borderland between the Pre-Cambrian Adirondack Highland and the St. Lawrence Valley Paleozoic plain, the outlet for the lake was at Covey Hill, Quebec, Canada. The ancestral Salmon River, flowing northward from the Adirondack Highland, built a large delta out into Lake Iroquois. This delta has been dissected by postglacial erosion, so that only fragments of the original form remain. Remnants of this delta include the hills at the Paro, Railroad, and Nichol pits. At the Paro pit a complete section through the delta has been revealed. At the bottom is the glacial till on which the delta was deposited. Above this occur the clayey bottom-set beds of typical delta structure, with the progressively coarser material extending upward to the top of the deposit.

(d) Estimated Quantity - It was estimated that there are over 2 million cubic yards of sand and gravel in the entire deposit. This was based on exploration at the Paro Pit and observation of the exposed pit faces in the Nichol and Railroad pits. In order to obtain more accurate knowledge of the extent of this deposit, it would be necessary to drill at various points.

(e) Method of sampling. - Only the Paro Pit was sampled, as it was believed the material in this pit was representative of the area. The pit was sampled by excavating a series of 6 ft. by 7 ft. steps in the pit face. Thirty-four steps with a total rise to the top of 154 feet were excavated. A 400-pound sample was taken from each step, and, after quartering and sieving the material over the 4", 2", 1", and ¼" screens, the separated sizes of gravel and sand were shipped to the Central Concrete Laboratory, West Point, New York.

(f) Appearance of Material - In general the material from this deposit was clean and fairly well graded. There was a high percentage of silt in some strata. Some disintegrated and rotten stone were encountered. The deposit is variable, grading from fine sand on the south to coarse gravel on the north. The whole deposit has an average gravel/sand ratio of approximately 60/40.

(g) Laboratory tests - The results of the routine tests made on sand and gravel are shown in Tables S-A-3/3 and S-A-3/4, and the results of special tests on these materials are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix. No studies of concrete in which material from these pits was used were made because of the meager data available.

(h) Recommendations - The results of durability tests showed this material to be unsound and therefore its use for concrete is not recommended.

12. <u>Parishville Sand Deposit, Parishville, New York.</u>

(a) Location - The Parishville deposit (Pits 1200 to 1203) comprises about 14 square miles. Its location is shown on map S-A-3/17 in this appendix. Two small pits, 3/8 mile north and ½ mile west of Parishville, respectively, have been used to supply aggregate for local construction. There is no railroad within 10 miles of this deposit, and the distance from Massena by highway is approximately 23 miles.

(b) Geology - The region in the vicinity of Parishville is a large delta originally developed by a large stream which flowed into glacial Lake Iroquois. The delta has since been dissected by streams and headward erosion and has in spme places been cut to bedrock.

(c) Quantity represented - A very large quantity of fine to medium sand is available in this area. Subsurface investigations were made chiefly to determine if sand of a coarser gradation could be found.

(d) Method of sampling - A total of 44 auger borings and small test pits, ranging in depth from 4 to 20 feet, were excavated. The location of the borings and pits are shown on a map, "General Plan, Parishville & Vicinity", inin the district files.

(e) Appearance of material - In general the aggregate in this deposit consisted of a uniform fine to medium sand, entirely too fine for use in concrete. Small deposits of dirty sand and gravel and of clean, coarse sand were located, but these were too limited for consideration.

(f) Laboratory tests - The results of routine laboratory tests made on sand from this area are shown in Table S-A-3/3 in this appendix.

(g) Study of structures - No performance studies of concrete in which sand from this area was used were made because of the meager data available.

(h) Recommendations - No further consideration of this area is believed advisable, since the detailed exploration showed the region to be lacking in sand of the proper gradation for use as concrete fine aggregate.

EXPLORATION AND SAMPLING OF AGGREGATE SOURCES IN CANADA

The area between the Ottawa and St. Pawrence Rivers, from Kingston, Ontario, to Joliette, Quebec, was explored for sources of suitable concrete aggregates. The exploration of the five most promising sources are described below:

1. <u>Mille Roches Limestone Deposit (Black River formation)</u>.

   (a) Location - This deposit, owned by the Gypsum, Lime, and Alabastine Company, Limited, Paris, Ontario is located one mile north of Mille Roches, and is shown on map S-A-3/17 in this appendix. Construction of one mile of track on an existing road-bed would permit rail transportation over the Canadian National Railroad to Cornwall Junction, a distance of 5 miles. There are 7 small quarries in this area, but at the time of the inspection no material was being removed. Stone from these quarries was used for masonry along the Cornwall Canal.

   (b) Geology - The limestone in this vicinity belongs to the Black River formation. Although both this formation and the Beekmantown dolomite formation are Ordovician in age, the former is considerably the higher stratigraphically. This stone is nearly horizontally bedded, with many thin stylolite seams and fossils. It appears to be generally sound and unweathered. It is dark gray in color and has an apparent specific gravity of 2.71. Numerous outcrop of Black River limestone were located in this area (see map S-A-3/33) in this appendix). Many of these are not owned by the Gypsum, Lime, and Alabastine Company. In the Mille Roches vicinity there is a sufficient quantity of limestone, with shallow overburden, to furnish coarse aggregate for the St. Lawrence River Project.

   (c) Method of Sampling - Samples of the limestone were crushed to 2-inch maximum size and shipped to the Central Concrete Laboratory, West Point, New York. The locations of three drill holes made in this area are shown on drawing S-A-3/3, Sheet 135 Folio of Subsurface Investigation, Appendix <u>B-1</u>.

   (d) Laboratory tests - The results of routine laboratory tests are shown in Table S-A-3/4, and the results of special tests are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix. The results of 34 cycles of freezing and thawing on 59 core samples indicated this material to be amply resistant. The description of these tests and photographs showing appearance of cores before and after freezing are in the district files.

   (e) Study of structures - An examination of the masonry in the Cornwall Canal indicated that, in general, this rock has satisfactorily withstood weathering for many years. A few of the masonry blocks showed appreciable disintegration obviously caused by a concentration of stylolite seams.

   (f) Recommendations - Limestone from this deposit is considered satisfactory for use as concrete coarse aggregate. It is possible however, that selective quarrying will be necessary to avoid rock layers which contain an excessive amount of shale.

2. Richmond Sand and Gravel Deposit, Richmond, Ontario.

(a) Location - This deposit (Pit 405, 406, 407) is located 5 miles northwest of Richmond, Ontario. The area investigated is approximately 3 miles long and ¼ mile wide. There are three small pits from which sand and gravel for local use have been obtained. Rail shipment to Cornwall Junction, probably the most economical method of transportation, would be as follows: 1 mile to the Canadian Pacific Railroad at Stittville; 18 miles to Ottawa via the C.P. R.R.; 55 miles to Cornwall Junction via the New York Central Railroad; total distance, 74 miles.

(b) Geology - This deposit is a typical marine beach which has been developed by wave action in the Champlain Sea. The material was derived from the underlying and adjacent Paleozoic rocks which outcrop extensively in that vicinity.

(c) Quantity represented - It is believed that the deposit contains in excess of 4 million cubic yards of sand and gravel, having an approximate gravel/sand ratio of 25/75. This estimate is based solely on geologic reconnaissance and field observations, and should be substantiated by a limited test-pitting and drilling program.

(d) Method of sampling - Representative samples of sand were taken from the three small commercial pits. After combining and quartering this material, large samples were stored for use in concrete tests in Massena and small samples were shipped to the Central Concrete Laboratory, West Point, New York, for routine tests. The sand from this deposit was found to be clean and fairly well graded, with little shale, rotten stone, or shale visible.

(e) Laboratory tests - The results of the routing aggregate tests made on sand from the Richmond deposit are shown in Table S-A-3/3, and the results of special tests on this material are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(f) Recommendations - The Richmond sand is representative of the large beach deposits in Northern New York and Southern Canada. It should be tested further to determine what, if any, correlation exists between unsoundness as indicated by the magnesium sulfate soundness test and unsoundness as measured by the resistance of concrete to severe weathering tests.

3. Grenadier Island Sand and Gravel Deposit, Grenadier Island.

(a) Location - Grenadier Island is located in the St. Lawrence River approximately 4 miles northeast of Alexandria Bay, New York, and about 70 miles upstream from Barnhart Island. There are three main sources of aggregate on the Island: (1) Pit 2001, in the northeastern part, owned by Dufferin Paving and Crushed Stone, Limited, Toronto; (2) Pit 2002, adjoining the Simpson property, owned by the Poole Estate, Grenadier Island; and (3) Pit 2003, in the southwestern part, owned by the Simpson Sand Company, Brockville. There is no plant equipment or material producing operations on Grenadier Island. Simpson operates a small sucker dredge in Pit 2003 to obtain sand for use in Brockville.

(b) Transportation facilities - The most favorable method for transporting aggregate from Grenadier Island to the sites of the various construction projects would be by barge. If a railroad haul were desired, material could be barged 15 miles to Brockville, Ontario, Canada, trans-loaded to the Canadian National Railroad, and shipped via rail 57 miles to Cornwall Junction.

(c) Geology - Like all the islands in the vicinity, Grenadier is a bedrock island. The rock is a pink Algoman granite or gneiss. On this irregular Pre-Cambrian rock surface, aqueo-glacial deposits were laid down during the retreat of the last ice sheet. These deposits consist of material which was washed off the edge of the ice or into depressions in the surface of the ice and are now apparent in the long ridges at both ends of the island and in the two symmetrical, kame-like hills which are the most prominent topographic feature at the southwest end of the island.

(d) Quantity represented - It is estimated that there are at least 3,000,000 cubic yards of sand and gravel on Grenadier Island. This figure is based on the results of the test pits previously excavated by the owners and on geologic reconnaissance. A detail map in the district files shows the location of proposed test pits, trenches, and drill holes which would be necessary to confirm this figure.

(e) Method of sampling - In pit 2001, Gravel Bay, Dufferin property, a trench, 6 feet deep and 18 feet long, was excavated in the exposed pit face. Thirty-four cubic feet of aggregate were taken at various points in the trench. The remainder of the samples were obtained by clam shell to a depth of 5 feet below water level. All of the above samples were quartered, screened on 4", 2", 1", and ¼" sieves, and the separated sizes shipped to the Central Concrete Laboratory, West Point, N. Y., for testing. Although Pit 2002 was sampled, no tests were made on the material because it was considered similar to that from pits Nos. 2001 and 2003. As Pit 2003 was entirely under water, samples of sand were obtained at a depth of 30 feet by the use of a sucker dredge. The aggregate in this region is approximately 10 percent gravel.

(f) Appearance of material - In general the sand and gravel from these pits were found to be clean and fairly well graded with considerable disintegrated and soft material. The gravel/sand ratio was estimated to be 50/50, with sizes ranging from boulders to fine sand.

(g) Laboratory tests - The results of the routine aggregate tests are shown on Tables S-A-3/2 and S-A-3/4, and the results of special tests on these materials are shown under the heading "Special Tests on Aggregates, Cement and Concrete" in this appendix.

(h) Study of structures - Aggregate from Grenadier Island was reported to have been used in concrete in the following structures:

Prescott Grain Elevators, Prescott, Ontario.
Phillips Wire Plant, Brockville, Ontario.
Monitana Hotel, Brockville, Ontario.
Lyons Grinding Co. buildings, Brockville, Ontario.

With the exception of the elevators, the concrete in these structures showed no appreciable evidence of structural weakness due to aggregate failure. Several "popouts" caused by weathered dolomite were found in the Prescott Elevators.

(I) Recommendations - The results of tests on this sand and gravel combined in concrete indicated a serious lack of durability; therefore the material is not recommended. Further tests on the sand from this deposit are recommended.

4. Joliette Sand Deposit, Joliette, Quebec.

(a) Location - This deposit, owned by the Standard Lime Company of Joliette, P.Q., Canada, is located 10 miles northeast of Joliette, and 45 miles north of Montreal. The Standard Lime Company is a subsidiary of the Gypsum, Lime, and Alabastine Company, Ltd., of Paris, Ontario. The pit has been operated for 25 years and during that time approximately 2 million tons of material have been removed.

(b) Transportation facilities - Either rail or barge shipment of sand from this deposit to Cornwall would be possible. The sand could be hauled to Berthierville, Canada, a distance of approximately 18 miles, on the Canadian National Railroad and then transferred to barges for water shipment to Cornwall. The distance, either by rail or by water, is about 125 miles.

(c) Present operations - A screening and washing plant, capable of producing 1000 tons of sand every 24 hours, is now operating in this pit. Sand from this deposit has been used extensively in concrete construction in Montreal.

(d) Quantity represented - It was estimated that there is sufficient sand in this deposit to supply all concrete fine aggregate requirements for the St. Lawrence River Project.

(e) Method of sampling - Representative samples were taken from stockpiles of processed sand. After thoroughly mixing and quartering, samples were shipped to the Central Concrete Laboratory, West Point. New York.

(f) Appearance of Material - Processed sand from this deposit was found to be clean and very well graded, with little or no soft, friable, or micaceous particles.

(g) Laboratory tests - The results of routine tests made on sand from this deposit are shown in Table S-A-3/3 in this appendix. No performance studies of concrete in which sand from this region was used have been made by this office.

(h) Recommendations - It is believed that this sand is satisfactory for use in concrete.

5. <u>Oka Sand Deposit, Oka, Quebec</u>.

(a) Location - This deposit, owned by the Consolidated Oka Sand and Gravel Company, Montreal, Province of Quebec, Canada, is located near Point Calumet in the Lake of Two Mountains, Ottawa River, approximately 8 miles northeast of Oka, Quebec. The sand is obtained at a depth of 25 feet below the lake surface.

(b) Transportation facilities - It is probable that barge transportation would be the most economical method of transporting sand from the Oka deposit to Cornwall. The distance by barge is about

70 miles. However, the sand could be transferred from barges to railroad cars at Vaudreuil and shipped to Cornwall over the Canadian National or Canadian Pacific Railroads.

(c) Present operations - There have been dredging operations in this deposit for the past 35 years. Over five million tons of sand have been removed. At the time of the inspection a large suction dredge, capable of producing 250 tons of washed sand per hour, was in use. The sand was taken to Montreal in 1000-ton barges.

(d) Geology - The deposit of sand laid down in the Lake of Two Mountains is apparently alluvium carried into the lake by the Ottawa River. The material is composed chiefly of mineral aggregates derived from Pre-Cambrian crystalline rocks.

(e) Quantity represented - It was estimated by the superintendent of the pumping plant that this deposit contained approximately 1 million tons of sand. No exploration of this area has been conducted by this office.

(f) Appearance of material - Samples taken at the pumping plant showed this sand to be clean with the exception of a small amount of minute micaceous particles. It did not comply with present Federal Specifications as to grading, since it was dificient in material passing the #50 and #100 sieves. It is possible that the grading can be adjusted by a change in processing methods.

(g) Laboratory tests - The results of routine laboratory tests made on this material are shown in Table S A-3/3 in this appendix.

(h) Study of structures - No performance studies of concrete in which sand from this region was used were made.

(i) Recommendations - More detailed investigation of this deposit is not recommended unless the material is offered specificly for the St. Lawrence River Project.

6. Other Deposits - Aside from the five deposits described above, many other sand, gravel, and stone deposits in Canada were investigated. The location of these deposits are shown on Canadian Quadrangles S-A-3/17 to S-A-3/28, and S-A-3/33 to S-A-36. The pit number, local name, type of material, estimated gravel/sand ratio, estimated quantity, location and estimated possibility for use are given in Tabulation S-A-3/37 in this appendix. Field inspection reports covering all aggregate deposits located in Canada are included in the file of field inspection reports in the district files.

Memorandum to:

G. A. Lindsay, Esq.
Chairman, Canadian Committee
St. Lawrence Deep Waterway
International Rapids Section.

The following memorandum is submitted in response to the request made to the Testing Laboratories of the Department of Public Works and to the Geological Survey for assistance in locating possible supplies for concrete aggregates.

Mr. E. Viens acted for the Testing Laboratories, Miss A. E. Wilson for the Geological Survey. Mr. L. R. Stratton, engineer of the Department of Transport viewed all deposits selected.

An area was covered extending approximately from 74° 25' lat. on the east to a line on the west, drawn from 76° 42' to 75° 50' lat. and from the margin of the Canadian Shield to the International Boundary on the north and south respectively; that is from Hawkesbury and Baudette River on the east to Renfrew, Mississippi Station and Brockville on the west.

The areas selected as the most probable sources of aggregate are marked on the appropriate Canadian Quadrangles included herewith.

- - - - - - - - - - -

The examination and selection of deposits suitable for testing resolved itself into three phases.

1. The reason the natural gravels could not be used.
2. Selection for large aggregate.
3. Selection for fine aggregate.

1. An examination of the concrete forming the Prescott Terminal elevator and of the gravel pit from which the aggregate was taken revealed that the weathered Beekmantown dolomite caused "pop-outs". The dolomite is composed of calcium and magnesium carbonates. The calcium carbonate weathers first leaving an outer porous envelope of magnesium crystals which, within the interstices, retains water which cannot be absorbed. An area of many scores of miles is underlain by these dolomites. Any gravels formed by glacial action over Beekmantown dolomite will have this defect.

A visit was made to gravel pits in areas underlain by the purer Black River-Trenton limestone. It was found that in them also, there is too high a percentage of weathered dolomite derived in part from Beekmantown dolomite exposures farther north transported by glacial action, and in part from the few dolomite layers within the limestones themselves.

Practically all the sand deposits in the Ottawa-St. Lawrence lowlands are of sea sand from the last post-glacial marine invasion. The sand is too fine for concrete purposes.

Therefore it was realized that the natural deposits of gravel and sand would have to be abandoned for crushed rock for large aggregate and glacial sands derived from Precambrian rocks for fine aggregate.

2. In selecting sources of crushed rock for large aggregate those outcrops of limestone suitable in nature and quantity were visited and the most probable selected for later tests. Beekmantown dolomite in its unweathered condition was included as well as Black River-Trenton.

Pending tests, possible sources for large aggregate near the project are:

i) Trenton limestone hill, 2 miles long, Indian Lands, Cons. VIII

& IX, Glengarry tp. and lots B. and C. Con. IX, Roxborough tp., Glengarry co. - Pit #19, Cornwall Quadrangle.

ii) Black River limestone, one mile north of Mille Roches, lots 24, 25 and 26, Con. IV, Cornwall tp., Glengarry co. - see Cornwall Quandrangle.

iii) Black River limestone, 3 miles north of Cornwall, lots 1 to 9 Con. IV, Cornwall tp., Glengarry co. - see Pit #18, Cornwall Quadrangle.

iv) Beekmantown dolomite, in an area one mile west of Cardinal, lots 9 to 12 Con. 1, Edwardsburg tp., Grenville Co. - see Pit #108, Morrisburg Quadrangle.

v) Beekmantown dolomite, 3 miles north of Johnstown, lots 25 to 28, Con III, Edwardsburg tp., Grenville co. - see Pit #107, Morrisburg Quadrangle.

vi) Beekmantown dolomite, just north of Spencerville, lots 27, 28 and 29, Con VI and VII, Edwardsburg tp., Greenville Co. - see Pit #300 Merricksville Quadrangle.

Several Precambrian quartzite areas were also visited, west of Oxford Station and in the general area farther east, lots 20, 21, 29, and 30, Con. VIII, Oxford tp. and lot 11, Con. III, S. Gower tp., Grenville co.

3. In selecting sand for fine aggregates an inspection was made within the area of every known pit containing sand of desirable grading and sufficiently free from weathered dolomite. No pit with these requirements had a sufficient quantity of material. The sand had to be selected within or on the margins of the Precambrian areas.

Possible sourses for fine aggregates are:

i) 2 miles east of Renfrew, lots 6 and 7, Con. III, Horton tp., Renfrew co. - Pit #1300, Renfrew Quadrangle.

ii) 3 miles northeast of Lanark, lots 3 and 4, Cons. IV and V, Lanark tp., Lanark co. - Pit #700, Carleton Place Quadrangle.

iii) 2½ miles south of Mississippi Station, lots 3 and 4 Con. VIII, Palmerston tp., Lenox and Addington co. - see Pit #1400, Sharbot Lake Quadrangle.

iv) The Grenadier Island locality was not visited. The sand is in the river bed and no estimate can be made of the quantity without testing its depth. The sand was examined, however, in the yards at Brockville.

With the exception of the fine aggregate deposit northeast of Lanark all localities mentioned for large and fine aggregate are either on railway lines or within four miles of a line. The Lanark sand deposit is some 10 or 12 miles from Perth or Carleton Place.

Visits were made to Massena to consult with the United States Army engineers and to examine what they had found.

The United States Army engineers and geologists interested in concrete materials were taken to see the selected rock exposures for large aggregate and sand supplies for fine aggregate.

S/ A. E. Wilson.
E. Viens.

Ottawa, December 20, 1941.
COPY DS.

ST. LAWRENCE RIVER PROJECT
CONCRETE AGGREGATE INVESTIGATION
Field Inspector's Report and Record of Samples Taken

QUADRANGLE Santa Clara   PIT NO. 1401   TYPE OF MATERIAL Sand & gravel

NAME AND ADDRESS OF OWNER A.H. Trotter. Friend Smith, Santa Clara, N.Y., agent

DATE INSPECTED 6-24-41   INSPECTED BY H.A.V. - S.M.M.

TYPE OF DEPOSIT Aqueo-glacial.

LOCATION AND DESCRIPTION OF PIT Near village of Santa Clara, N. Y. Pit overgrown by vegetation. Not used for 11 years. Gravel/sand ratio 30/70.

EST. QUANTITY MATERIAL REMOVED 10,000 cu. yds. EST. WORKABLE DEPTH 50 feet

APPEARANCE OF MATERIAL Clean, fairly well-graded sand and gravel. No shale, rotten stone or shells visible. Several veins of magnetite present.

AVAILABILITY OF WATER St. Regis River nearby

QUANTITY (CU. YDS.) EST. BY OWNER ___________ BY INSPECTOR 1,000,000

DISTANCE FROM MASSENA, BY R.R. *59 miles   BY TRUCK 35 miles

PLANT EQUIPMENT None (The Santa Clara Sand Co. used to operate in this pit. Concrete foundations made with this sand are still apparently sound).

PROJECTS FURNISHED Bridge west of Brushton, N. Y. (1929)

NO. SAMPLES & WHERE TAKEN 300 lbs. from trench cut in face of pit.

INSPECTOR'S RECOMMENDATIONS Further investigations necessary to check the quality of the material and the extent of the deposit if economical transportation can be obtained.

LAB. SAMPLE NO.	DATE SUBMITTED	DATE TESTED	REMARKS
STL-S-35	6/27/41	7/28/41	$MgSO_4$ loss (11.9%)

*Necessary to construct an 18-mile R.R. from Santa Clara to Moira over existing roadbed.

ST. LAWRENCE RIVER PROJECT
CONCRETE AGGREGATE INVESTIGATION
Field Inspector's Report and Record of Samples Taken
Canada

QUADRANGLE Cornwall PIT NO. Mille Roches TYPE OF MATERIAL Limestone

NAME & ADDRESS OF OWNER Gypsum, Lime & Alabastine Co., Ltd., Paris, Ontario, Canada.

DATE INSPECTED 7/2/41 INSPECTED BY J.L.R. - H.A.V.

TYPE OF DEPOSIT Limestone, Black River formation.

LOCATION AND DESCRIPTION OF PIT Approx. 2 m. N. of Mille Roches, P.O. Canada. Seven small quarries scattered in area one mile long.

EST. QUANTITY MATERIAL REMOVED 50,000 Cu. Yds. EST. WORKABLE DEPTH 100 Ft.

APPEARANCE OF MATERIAL Clean, fossiliferous limestone with many stylolite seams.

AVAILABILITY OF WATER Ground Water near surface.

QUANTITY (CU. YDS.) EST. BY OWNER ________ BY INSPECTOR unlimited

DISTANCE FROM CORNWALL JUNCTION BY RR After 1 m. spur to Milles Roche is built, 4 miles. BY TRUCK- 3 miles from Long Sault Dam S.

PLANT EQUIPMENT None

PROJECTS FURNISHED Masonry in Cornwall Canal; Canadian National R.R.

NO. SAMPLES & WHERE TAKEN 1-ton sample sent to Central Concrete Lab., West Point, N. Y.

INSPECTOR'S RECOMMENDATIONS Petrographic analysis, physical tests, and durability studies indicated satisfactory quality.

LAB. SAMPLE NO.	DATE SUBMITTED	DATE TESTED	REMARKS
STL-G-1	1/20/41	2/10/41	0.5% loss after 25
STL-G-36	8/12/41	8/15/41	cycles of Freezing
STL-G-37	8/12/41	8/15/41	and Thawing.

TABLE NO. 1. RESULT OF LABORATORY TESTS ON FINE AGGREGATE
(Central Concrete Laboratory, West Point, New York)

Serial Desig.	Pit No.	Sieve Analysis-% Passing Sieve Size No. 4	8	16	30	50	100	Sp. Gr.	Per Cent Absorption 24	48	7d	Unit Wt. **	% Voids	Comp. Str. Ratio 3d	7d	MgSO4 % loss 10 cyc.	Decant. Loss %	Type of Material
STL-S-1	1203	99	97	91	63	17	2	2.64	0.6	-	-	101	39.0	75	87	8.1	1.0	Sand
S-2	1203	100	92	77	42	5	1	2.63	0.6	-	-	100	39.3	70	90	7.9	0.5	"
S-3	202	100	72	40	12	4	2	2.67	0.6	-	-	109	34.6	79	84	23.6	1.1	"
S-4	202	94	70	52	36	17	6	2.66	0.4	-	-	114	31.3	87	89	22.1	1.0	"
S-5	9	98	86	60	31	9	3	2.69	0.9	-	-	107	36.3	79	80	15.9	1.0	"
STL-S-6	*2001	100	79	46	21	8	4	2.69	1.0	-	-	107	36.6	96	94	16.3	1.2	Sand
S-7	*2003	100	99	95	74	22	4	2.70	1.0	-	-	101	40.3	100	104	26.4	1.8	"
S-8	11	100	82	60	40	22	8	2.67	1.0	-	-	114	31.7	91	94	25.7	4.4	"
S-9	11	100	89	77	54	16	7	2.63	1.0	-	-	108	34.4	88	95	14.9	5.0	"
S-10	100	100	83	64	46	27	15	2.67	0.8	-	-	117	29.7	96	100	24.2	7.4	"
STL-S-11	10	100	84	67	48	18	7	2.64	1.3	-	-	111	34.1	89	84	48.5	6.2	Sand
S-12	8	100	68	42	27	18	12	2.82	0.3	-	-	120	32.0	106	103	2.7	1.8	Dolomite
S-13	8	100	76	50	33	22	15	2.82	0.3	-	-	120	31.6	98	100	5.4	2.2	"
S-14	8	100	67	41	26	17	12	2.82	0.3	-	-	121	31.3	104	92	-	0.0	"
S-15	8	100	76	47	30	21	15	2.82	0.3	-	-	126	28.4	94	90	-	0.0	"
STL-S-16	8	96	38	15	7	5	4	2.82	0.3	-	-	111	36.8	94	96	-	0.0	Dolomite
S-17	1600	77	17	3	1	1	0	2.96	0.3	-	-	-	-	-	-	2.8	-	Syenite
S-18	200	100	84	55	17	6	5	2.71	1.9	-	-	-	-	88	88	46.2	-	Sand
S-19	803	89	71	57	43	14	3	-	-	-	-	-	-	-	-	14.1	-	"
S-20	1000	93	80	63	35	11	6	-	-	-	-	-	-	-	-	9.4	-	"
STL-S-21	900	97	74	50	27	7	3	-	-	-	-	-	-	-	-	9.0	-	Sand
S-22	5400	95	74	54	39	18	3	-	-	-	-	-	-	-	-	18.4	-	"
S-23	*2001	94	72	40	16	5	2	-	-	-	-	-	-	-	-	-	-	"
S-24	*2002	99	92	71	41	9	2	-	-	-	-	-	-	-	-	-	-	"
S-25	*2003	92	68	36	13	5	2	-	-	-	-	-	-	-	-	-	-	"
STL-S-26	*(a)	93	87	75	46	15	4	-	-	-	-	-	-	-	-	4.3	-	Sand
S-27	*(b)	100	97	71	22	6	1	-	-	-	-	-	-	-	-	11.6	-	"
S-28	*(c)	88	79	66	49	27	10	-	-	-	-	-	-	-	-	8.6	-	"
S-28A	*(d)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.7	-	Sandstone
S-29	7	94	79	54	23	7	4	-	-	-	-	-	-	-	-	38.0	-	Sand
S-30	707	91	75	59	36	11	3	-	-	-	-	-	-	-	-	16.3	-	"
STL-S-31	*(e)	93	67	41	23	9	3	2.64	0.9	0.9	1.0	113	31.7	95	92	27.7	2.7	Sand
S-32	*2001	91	57	35	24	11	4	2.65	1.0	1.2	1.2	115	30.8	92	93	31.0	3.8	"
S-33	*2001	91	62	38	27	13	4	2.64	1.2	1.3	1.3	117	28.9	98	92	20.6	3.6	"
S-34	*2003	99	83	49	19	4	1	2.65	1.1	1.2	1.2	106	35.7	96	91	23.5	0.8	"
S-35	1401	97	90	81	62	22	5	2.65	0.5	0.7	0.7	106	36.0	103	102	11.9	0.8	"
STL-S-36	202	91	65	46	32	17	8	2.64	1.1	1.2	1.2	116	29.6	92	92	27.8	5.1	Sand
S-37	202	88	59	39	26	13	6	2.64	1.0	1.1	1.1	117	29.4	80	79	28.9	5.4	"
S-38	202	86	48	23	12	6	3	2.65	0.9	1.0	1.0	115	30.5	78	76	25.7	2.8	"
S-39	202	91	62	37	21	9	4	2.65	0.8	0.9	0.9	116	30.0	77	85	26.3	2.2	"
S-40	202	88	53	33	23	12	5	2.65	0.7	0.9	1.0	117	29.6	83	88	28.3	2.9	"
STL-S-41	202	89	64	47	35	20	9	2.66	0.7	0.8	0.9	116	30.3	92	87	29.9	5.8	Sand
S-42	202	87	56	39	30	18	9	2.65	0.7	0.7	0.8	116	30.0	125	114	27.0	5.4	"
S-43	202	90	65	52	41	26	13	2.63	0.8	0.8	0.8	116	29.6	88	90	29.0	8.2	"
S-44	1600	100	99	73	48	16	3	2.94	0.1	0.2	0.2	111	39.6	99	95	9.1	0.6	Syenite
S-45	8	100	93	45	10	3	2	2.79	0.2	0.3	0.3	98	44.1	101	87	-	2.6	Dolomite
STL-S-46	8	100	100	100	91	68	51	2.78	0.3	0.3	0.4	112	35.6	101	87	-	1.6	Dolomite
S-47	*900	100	92	74	34	15	4	2.65	0.7	0.9	1.0	-	-	96	94	22.1	2.4	Sand
S-48	*405	100	88	63	46	25	6	2.65	0.6	1.0	1.0	-	-	94	92	18.7	1.8	"
S-49	*300	100	77	55	37	13	4	2.74	0.5	0.7	0.7	112	34.6	99	96	24.0	1.6	"
S-50	1501	99	86	68	42	13	3	2.67	0.4	0.5	0.5	109	34.9	85	91	9.7	0.2	"
STL-S-51	*802	99	92	80	40	6	2	-	-	-	-	-	-	-	-	17.2	-	Sand
S-52	6001	96	90	73	36	9	3	-	-	-	-	-	-	-	-	9.0	-	"
S-53	6002	98	95	82	43	13	2	-	-	-	-	-	-	-	-	6.0	-	"
S-54	2600	83	60	38	24	12	7	-	-	-	-	-	-	-	-	21.4	-	"
S-55	6003	94	84	73	54	24	6	-	-	-	-	-	-	-	-	7.7	-	"
STL-S-56	1209	94	86	78	61	21	2	-	-	-	-	-	-	-	-	14.7	-	Sand
STL-S-57	(f)	100	100	95	43	3	0	-	-	-	-	-	-	-	-	10.6	-	"
STL-S-58	1000	95	83	76	47	14	5	-	-	-	-	-	-	-	-	20.2	-	"
STL-S-59	900	92	80	66	35	10	2	-	-	-	-	-	-	-	-	15.7	-	"
STL-S-60	6005	95	89	77	46	14	3	-	-	-	-	-	-	-	-	5.7	-	"
STL-S-61	5200	98	90	70	34	6	0	-	-	-	-	-	-	-	-	4.9	-	Sand
S-62	5201	98	94	69	22	4	1	-	-	-	-	-	-	-	-	5.4	-	"
S-63	5202	97	88	70	51	17	2	-	-	-	-	-	-	-	-	4.2	-	"
S-64	5203	98	95	80	42	7	1	-	-	-	-	-	-	-	-	5.9	-	"
S-65	5204	98	91	69	27	8	2	-	-	-	-	-	-	-	-	4.4	-	"
STL-S-66	*1400	95	81	59	35	14	5	-	-	-	-	-	-	-	-	13.3	-	Sand
S-67	*700	92	72	48	32	15	4	-	-	-	-	-	-	-	-	24.8	-	"

S-A-3/3

* Canadian aggregate deposits.
** In accordance with "Standard Method of Test for Unit Weight of Aggregate, ASTM Desig. C29-39"
(a) Deposit located 10 miles northwest of Joliette, P.Q., Canada.
(b) Deposit located in Ottawa River, 8 miles northeast of Oka, P.Q., Canada.
(c) Old stockpile, Chute-a-Caron Dam, Arvida, P.Q., Canada.
(d) Old stockpile of crushed Potsdam sandstone, Beauharnois, Dam, Beauharnois, P.Q., Canada.
(e) Composite sample, Pits 2001 and 2003, Grenadier Island.
(f) Sand from Lake Ontario, delivered to Ogdensburg, N. Y. by barge, by the Tees Transport Company.

Note: Colorimetric Test, A.S.T.M. desig. C40-33, made on these sands showed satisfactory with the exception of samples STL-S-1 and STL-S-2.

TABLE NO. 2. RESULTS OF LABORATORY TESTS ON COARSE AGGREGATE
(Central Concrete Laboratory, West Point, New York)

Serial Desig.	Pit No.	Sieve Analysis-% Passing, Sieve Size No. 4"	2"	1½"	1"	3/4"	½"	3/8"	#4	Sp. Gr.	Per Cent Absorption 24	48	7d	Unit Wt. **	% Voids	% Loss 10 cyc. $MgSO_4$	% Loss 25 cyc. F & T	Type of Material
STL-G-1	*(a)			Ungraded Material						-	0.5	-	-	-	-	-	2.4	Limestone
G-2	202	100	90	85	71	59	39	30	0	2.65	1.2	-	-	-	-	14.6	-	Gravel
G-3	8			Ungraded Material						2.83	0.3	-	-	-	-	-	0.7	Dolomite
G-4	*(b)			Ungraded Material						2.81	0.7	-	-	-	-	-	5.1	"
G-5	*(c)			Ungraded Material						2.81	0.6	-	-	-	-	-	5.0	"
STL-G-6	904			Ungraded Material						2.76	0.5	-	-	-	-	-	1.3	Dolomite
G-7	9	-	-	100	71	28	4	2	1	2.72	0.7	-	-	101	40.6	6.2	-	Cr. gravel
G-8	*2001	-	100	84	81	69	53	41	0	-	-	-	-	-	-	-	-	Gravel
G-9	11	100	93	88	66	51	31	21	0	-	-	-	-	-	-	-	-	"
G-10	11	-	-	98	88	73	49	36	0	-	-	-	-	-	-	-	-	"
STL-G-11	100	-	-	97	85	65	31	20	0	-	-	-	-	-	-	-	-	Gravel
G-12	10	-	-	99	97	86	62	46	0	-	-	-	-	-	-	-	-	"
G-13	*2001	-	-	-	100	82	54	27	1	2.64	1.1	1.3	1.4	104	37.2	20.7	-	"
G-14	*2001	-	100	70	4	0	-	-	-	2.67	0.7	0.7	1.0	102	38.8	8.7	-	"
G-15	*2001	100	0	-	-	-	-	-	-	2.68	0.7	0.9	0.9	-	-	0.0	-	"
STL-G-16	*2003	-	-	-	100	89	61	33	1	2.66	0.9	1.1	1.2	103	37.8	15.8	-	Gravel
G-17	*2003	-	98	58	4	1	-	-	-	2.66	0.6	0.8	0.8	102	38.6	7.6	-	"
G-18	*2003	100	0	-	-	-	-	-	-	2.62	0.7	0.8	0.9	-	-	9.5	-	"
G-19	202	-	-	-	100	80	49	31	2	2.65	1.0	1.0	1.1	106	35.8	16.1	-	"
G-20	202	-	100	58	3.5	0	-	-	-	2.66	0.8	0.9	0.9	103	38.4	5.6	-	"
STL-G-21	202	100	0	-	-	-	-	-	-	2.62	0.8	0.8	0.9	-	-	3.9	-	Gravel
G-22	8	-	-	-	-	-	-	99	20	2.82	0.7	0.7	0.7	99	43.6	-	-	Dolomite
G-23	8	-	-	-	-	-	100	58	0	2.84	0.3	0.3	0.3	91	49.0	-	-	"
G-24	8	-	-	-	80	34	8	3	0	2.84	0.4	0.4	0.4	97	45.6	-	0.2	"
G-25	8	-	100	81	7	1	-	-	-	2.84	0.2	0.2	0.2	96	46.1	-	0.1	"
STL-G-26	1600	-	-	-	-	-	-	100	44	2.87	0.2	0.2	0.2	102	43.4	-	-	Syenite
G-27	1600	-	-	-	-	-	99	67	0	2.92	0.2	0.3	0.4	102	44.1	-	-	"
G-28	1600	-	-	-	98	64	2	0	-	2.88	0.3	0.3	0.3	100	44.4	-	-	"
G-29	1600	-	100	87	5	0	-	-	-	2.89	0.5	0.5	0.5	101	44.2	-	-	"
G-30	30			Ungraded Material						2.81	0.5	0.5	0.5	-	-	-	-	Dolomite
STL-G-31	*900	Insufficient sample for Tests; Sand Phase (STL-S-47) Tested.																Gravel
G-32	*405	Insufficient sample for Tests; Sand Phase (STL-S-48) Tested.																"
G-33	*300	100	81	72	51	40	26	19	0	-	-	-	-	-	-	-	-	"
G-34	1501	-	-	-	100	84	51	35	5	2.68	0.8	0.8	1.2	88	47.3	5.5	-	"
G-35	1501	-	100	71	19	3	2	-	-	2.68	0.6	0.6	0.6	86	48.9	2.2	-	"
STL-G-36	*(a)	-	-	-	99	63	26	16	2	-	0.2	0.2	0.3	73	58.6	1.3	0.4	Limestone
G-37	*(a)	-	99	80	11	2	-	-	-	-	0.1	0.1	0.2	71	59.9	1.5	0.7	"

* Canadian aggregate deposits.
** In accordance with "Standard Method of Test for Unit Weight of Aggregate, ASTM desig. C29-39".
(a) Limestone quarries, Black River Formation, 1 mile north of Milles Roches, P.O., Canada
(b) Windmill Point quarry, dolomite rock, Beekmantown Formation, 1 mile northeast of Prescott, P.O., Canada.
(c) Railroad quarry, dolomite rock, Beekmantown Formation, Prescott, P.O., Canada.

SPECIAL TESTS ON AGGREGATES, CEMENT AND CONCRETE

SERIES A - Tests for Strength, Staining and Crazing, Density, Thermal Properties, and Chemical Reactivity at West Point, N. Y.; and Concrete Exposure at Treat Island, Maine.

1. General. - The following is a report on the concrete testing program conducted at the Central Concrete Laboratory, West Point, New York. Only materials which were representative of some of the major available sources of supply were included in this group of tests. The program included:

(a) A study of the relative durability of the various combinations of fine and coarse aggregate in concrete when subjected to weathering tests at Treat Island, Maine.

(b) A study of the effects of the different aggregates on the mix design, strength, staining and crazing, density, thermal properties, and chemical reactivity.

(c) Study of the influence of Vinsol resin, interground with the cement, upon the workability, economy, and durability of the concrete.

(d) Study of the influence of absorptive form lining on the durability of the conrete.

2. Materials.

(a) The aggregates used and their physical properties, as measured by standard laboratory tests, are shown in Table I and their mineral composition in Table II. The various types of fine aggregate were dried to a room-dry condition and were well mixed to insure uniform grading in all specimens. In proportioning for concrete, allowances were made for the absorption of moisture by the sands. The various types of coarse aggregate were dried to a room-dry condition, evacuated under 29 inches of vacuum for one hour, and then covered with water for a minimum period of 5 days. The specific gravity of the coarse aggregate was determined in the evacuated-saturated condition. In batching for concrete the coarse aggregates were weighed under water.

(b) Cement. The cements used met the requirements of Federal Specification SS-C-206a. The chemical and physical characteristics of the cements are given in Tables IIIa and IIIb. The entire quantity of cement for the program was obtained from one lot, well mixed at the laboratory and stored in closed containers.

3. Preparation of Concrete.

(a) Mixing of Batches. - All batches were mixed for 5 minutes in a mechanical mixer after a "butter" batch of the same concrete had been mixed and discarded.

(b) Molding of Specimens. - All specimens were molded by hand-rodding, augmented by hammer-tapping on the surface of the mold.

(c) Curing. - All specimens were cured for 14 days in limewater at a temperature of 72° F., + or - 3° F. The specimens were stored in laboratory air after the curing period until time of test, except as noted.

4. <u>Series A - Test Data.</u>

(a) Mix Design. - With an untreated cement and a water-cement ration fixed at 6.0 gallons per sack, the proportions of fine and coarse aggregate were varied to produce concrete mixtures of equal consistencies as measured by slump test (2½" slump). The mixtures determined under these conditions for the different combinations of aggregates are shown in Table IV.

(b) Compressive Strength. - The compressive strengths developed by these mixtures are given in Table VI. All specimens were cured in limewater until time of tests. The results of compressive strength tests on specimens made with the treated cement and absorptive form lining are also shown in Table VI.

(c) Flexural Strength. - The strengths developed by the mixtures shown in Table IV are given in Table VII. All specimens were cured in limewater for 14 days and then in laboratory air until tested at 28 days. The flexural tests were made with a concentrated load at the midpoint on an 18 inch span.

(d) Stain and Crazing. - The tendency of the aggregates to stain concrete surfaces and their influence upon crazing were observed by testing 3" by 20" by 20" slabs (plywood lined forms) prepared from the mixtures shown in Table IV. The tests consisted of subjecting 60-day-old slabs (14 days limewater followed by 46 days laboratory air) to repeated sudden immersion in warm water (125° F. + or - 5° F.) followed 15 minutes later by drying and cooling in dry air at a temperature of 40° F. + or - 5° F. This cycle was applied once daily for 20 days. No indication of staining or crazing developed on any of the slabs. The slabs were then placed out-of-doors where they were subjected to low temperatures during the night and sudden superficial warming by being doused with warm water (approx. 120° F.) each morning. During 32 days of this type of exposure the temperature dropped below 26° F. on 14 occasions. No signs of staining or crazing were apparent. The test was continued.

(e) Density. - The absorption, specific gravity, voids, and unit weight of the top and bottom sections of 6" by 6" by 48" columns of concrete made from the mixtures shown in Table IV are given in Table VIII.

(f) Cement Aggregate Alkali Reaction. - The tendency of any of the reactive minerals (opaline silica or feldspars) in the aggregates to react with the alkalies (Na and K) in Portland cement with resultant expansion of the concrete was studied as described below:

<u>1</u>. Beams (4" by 4" by 16") were molded from concrete containing each type of aggregate and a Portland cement containing 1.0% (considered a high value) of alkali. The beams were cured in limewater for 30 days and then were sealed hermetically in the presence of water. They were measured for length and modulus of elasticity (sonically) at the end of the curing period and at 180 days. There was no evidence of undue expansion nor was there a decrement in modulus of elasticity. The latter, if found, would have indicated incipient deterioration. As a matter of record, the modulii of elasticity are shown in Table IX.

<u>2</u>. Sections cut from the beams (described in <u>1</u> above) at 30, 60, 90, and 180 days were examined microscopically for evidence

of reaction between the aggregate matrix. No such evidence was detectable up to 180 days.

(g) Thermal Properties.

1. Diffusion Constant. - The coefficients of diffusion of heat through concrete made with these aggregates (Table IV mixtures) are given in Table Xa. The coefficient of diffusion (h^2) is a constant used in the calculation of heat flow through concrete. It may be calculated by the formula given below or it may be measured directly as was done in this investigation. Diffusivity constant (h^2) $= \frac{K}{C\,P}$ in square ft. per hour.

K = Conductivity in B.T.U./ft./hr./$^\circ$F.
C = Specific Heat in B.T.U./lb./$^\circ$F.
P = Density in pounds per cubic foot.

The normal range of diffusion constants for concrete lies between 0.03 and 0.60 Sq. Ft. per hour. Theoretically a concrete mass possessing a low diffusion constant will cool more slowly than one with a high diffusion constant.

2. Coefficient of Thermal Expansion. The coefficients of thermal expansion of the Northern Quarries dolomite, the Lyon Mountain syenitic rock, and certain minerals from the glacial gravel were determined for this office by the National Bureau of Standards by use of an optical interferometer. The coefficients are shown in Table Xb. The coefficients are given for heating and cooling. In cases where the expansion is essentially a straight line, only one figure for either heating or cooling is given. In cases where inflections occur, the ranges for the linear portions of the curves and their corresponding coefficients are given.

It is worthy of note that the red granite, the diabase, and the dolomite each have distinctive inflections in the "heating" curves.

It is worthy of particular note that the quartz and quartzite have coefficients roughly twice that of normal hardened Portland cement paste (6.0 to 8.0×10^{-6}).

The thermal coefficient of expansion of aggregate is of importance in its effect upon the coefficient of expansion of the concrete.

(h) Abrasion. - The surfaces of 6 x 12 inch concrete cylinders were sandblasted to determine the relative resistance to abrasion. A few specimens made with absorptive form lining showed greater resistance than did companion specimens molded against steel forms.

5. Accelerated Field Durability, Series A. - The resistance to accelerated weathering of four combinations of aggregate in concrete made with plain SS-C-206a cement and with Vinsol resin treated SS-C-206a cement, and with plain and absorptive forms was determined by installing 6" by 6" by 48" columns of each combination in the permanent exposure wharf at Treat Island (Eastport), Maine.

The following aggregate combinations were tested:

Symbol N - Crushed dolomite fine and coarse aggregate from Northern Quarries.
" L - " syenite " " " " " Lyon Mt.
" P - Glacial sand and gravel from Paro Pit.
" G - " " " " " Grenadier Island.

The characteristics of the aggregates are shown in Tables I, II, and

Xb, and the mixtures used are given in Table IV.

(a) Specimens. - The specimens used were 6" x 6" x 48" columns placed vertically in continuous one-foot courses to simulate a four-foot lift of concrete construction.

(b) Curing. - The specimens were cured in limewater for 14 days and in laboratory air until tested or installed on the Maine exposure rack at an age of approximately 45 days.

(c) Exposure. - The exposure rack at Treat Island is located at mean-tide elevation in a zone where the tide fluctuation varies from a minimum of 13 feet to a maximum of 26 feet. The mean tide fluctuation is 18 feet.

The sea-water attains a minimum temperature of 35 degrees Fahrenheit during the winter (never freezes). The atmospheric temperature varies from a normal minimum of -14° F., to a normal maximum of 40° F. during the winter. During the greater portion of the winter the air temperature ranges between 10° F. and 25° F.

The weather and tide conditions described above induce a reversal of freezing and thawing in an object at mean tide elevation twice daily on most days during the severe winter weather (December 10th-March 10th). The sudden immersion of the horizontally-placed concrete specimens with the rapidly rising tide and similarly sudden emersion with the ebbing tide induce sudden changes in temperature in the specimens of considerable magnitude, thus combining severe thermal shock with severe frost action.

(d) Measurement. - The modulus of elasticity was determined electro-sonically just prior to the initial freezing and after thawing at the periods shown in Table XIII. The modulii of elasticity of the specimens at the various inspection periods were compared with the modulii at the time of installation and the results are expressed in terms of the percent of the original modulii. The results are given in Table XIII.

SERIES B - Accelerated Laboratory Freezing and Thawing Tests at West Point, N.Y.

6. Series B Test Procedure. - The resistance to a special accelerated freezing and thawing test of six combinations of aggregate and plain SS-C-206a Portland Cement was determined.

(a) Aggregate Combinations. - The following combinations of aggregate were tested:

Symbol	Fine Aggregate	Coarse Aggregate
N	Crushed Northern Quarries dolomite	Crushed Northern Quarries dolomite
MN	Crushed Northern Quarries dolomite	Crushed Mille Roches limestone
Mo	Owls Head glacial sand	Crushed Mille Roches limestone
No	Owls Head glacial sand	Crushed Northern Quarries dolomite
G	Grenadier glacial sand	Grenadier glacial gravel
P	Paro glacial sand	Paro glacial gravel

Characteristics of the aggregates are shown in Tables I and II.

(b) Preparation of Concrete. - The preparation of the aggregate and cement, the mixing of batches, and the molding of specimens were as described in Paragraphs 2 and 3 above.

(c) Specimens. - The specimens used were $3\frac{1}{2}$" by $4\frac{1}{2}$" by 16" beams molded with the $3\frac{1}{2}$" by 16" faces lying horizontally.

(d) Mixtures. - A cement factor of 5.5 sacks per cubic yard was used for all combinations of aggregates except those in which crushed dolomite sand was used. In the latter case the cement content was increased to 5.75 sacks per cubic yard. The proportions of aggregate and water were varied to obtain the same consistency in all mixtures. The data for the various mixes are given Table V.

(e) Curing. - The specimens containing specially saturated aggregate were kept saturated at all times by curing in a limewater solution until subjected to freezing.

(f) The Freezing and Thawing Cycle. - The specimens were placed in an atmosphere of -10° F., in a dripping condition at the age of 14 days. They were reduced in temperature from 40° F. to 0° F. in $3\frac{1}{2}$ hours and were left in the low-temperature atmosphere for 5 hours; at which time they were removed and placed in water to thaw. The temperature of the specimens was permitted to rise to 40° F. after which they were again placed in the low-temperature atmosphere in a dripping wet condition. The freezing period of each even numbered cycle was 16 hours, at night. Freezing and thawing were repeated until the specimens developed indications of serious deterioration, or until 130 cycles were completed.

(g) Measurement. - The modulus of elasticity of the concrete was determined electro-sonically prior to the initial freezing and after thawing at the end of the numbers of cycles indicated in Table XI. The modulii of elasticity of the test specimens were compared with the modulii of identical control specimens stored continuously in water 70° F. + or - 3° F. The results; expressed in terms of the percentages of the values for the control specimen at equal ages, are given Table XI.

Another test of resistance was a comparison between the flexural strength of each freezing and thawing specimen and its companion control specimen. The results, including comments on the general appearance of the specimens at the end of the test, are given in Table XII.

The data in Tables XI and XII indicated that the glacial aggregates from Grenadier Island and the Paro pit are low in resistance in this type of test. The combination of crushed Northern Quarries dolomite sand and stone appeared to be the most highly resistant of all the combinations.

The crushed dolomite stone with Owls Head sand (NO) and the crushed Mille Roches limestone with Owls Head sand (MO) appeared to be satisfactory.

SERIES C - Concrete Freezing and Thawing Test at Massena, N. Y.

7. <u>Series C Test Procedure</u>. - The durability tests in Series A and B described above included aggregates from only a few of the larger deposits and did not provide sufficient comparisons between different fine aggregates. With further developments of the aggregate survey it appeared advisable to test several other fine aggregates and to compare them on the basis of their influence on the resistance ofconcrete to freezing and thawing. Information was sought concerning the relative effects of eight different sands (six natural, and two of crushed stone) each used in combination with crushed dolomite coarse aggregate. Ninety concrete beams were made and tested at the U. S. Engineer's warehouse at Massena, N. Y.

(a) Aggregates used: The fine aggregates used in making the specimens are shown in the following tabulation.

Source	Pit No.
Dolomite (manufactured from quarried rock)	8
Dolomite screenings (tailings from coarse agg. mfg.)	8
Premo natural sand (15.9% loss in $MgSO_4$)	9
Ha rtford natural sand (20.3% loss in $MgSO_4$)	11
Grenadier Isl., Canada, natural sand (23.6% in $MgSO_4$)	2001
Richmond, Ont., natural sand (18.7% loss in $MgSO_4$)	405-407
Lowville, N. Y., sand (4.5% loss in $MgSO_4$)	5200-5205
Owls Head, N. Y., sand (9.7% loss in $MgSO_4$)	1501

Crushed dolomite coarse aggregate was used with each of these sands and, in addition, Owl Head gravel was used with the Owls Head sand. This gave a total of nine aggregate combinations.

(b) Preparation of Aggregates. - The aggregates were washed and screened, and proportioned so that all batches had approximately the same gradation. The Owls Head gravel was immersed in water and let stand for seven days so that the pore space within the particles would be more nearly filled with water and cause the material to be in a condition least resistant to the freezing tests. The dolomite coarse aggregate was not soaked in water for this series of tests because this material had been found to have very low absorption. Previous tests had shown it to be thoroughly resistant even though completely saturated by the evacuation method prior to freezing. The gradations of all of the aggregates used are shown in Table XIV.

(c) Specimens. - Ten 3-5/8" x 4½" x 18" beams were made for each aggregate combination. The concrete for the ten specimens in each group was mixed by hand in onebatch and molded in paraffined wood molds.

(d) Mixtures. - Controlling features of the concrete mixtures were as follows:

Cement factor - 5.5 sacks per cubic yard.
Sand - 40 percent of total aggregate.
Slump - 2 - 3 inches.
Water - approximately 6 gallons per sack, but varied for the different materials in order to maintain equal consistency.

Other data on the concrete mixes are shown in Table XV.

(e) Curing. - The specimens were covered with wet burlap shortly after molding and kept wet for five days. The forms were then removed and wet burlap curing continued for one week longer, after which time the beams were cured in water until 28 days old.

(f) The freezing and thawing cycle. - The freezing was accomplished during cold weather by placing the specimens on a rack outside, near the U. S. Engineer Warehouse. The beams were thawed by placing in a tank of water at 50° F. - 60° F. inside the building. The temperature of the specimens when removed from the thawing tank was between 38° F. and 48° F. Two hours were permitted for thawing while the freezing time was dependent on the ambient atmospheric temperature. One half of the specimens of each group, or a total of forty-five beams, were subjected to freezing and thawing beginning at the age of 28 days.

(g) Flexure tests. - At the end of the 28-day curing period, one-half of the beams, companion specimens to those that were reserved for freezing and thawing, were tested in flexure. After 53 cycles had been completed the remaining beams were broken. The flexural strengths in pounds per square inch are given in Table XV. The facts and principal indications obtained from these tests are presented under appropriate headings in paragraphs 8 and 9.

8. Discussion of Results from Test Series A, B, and C. - Notwithstanding the limited scope of the laboratory studies and concrete exposure tests described above, considerable information of value was obtained and is discussed.

(a) From the results of the exposure tests on 12 colums (6" x 6" x 48") at Treat Island, Maine (See Table XIII), it was found that the crushed syenite (iron ore tailings) was the only aggregate represented in the test which continued to gain in modulus of elasticity up to 95 cycles. The specimens made with natural sand and gravel failed completely between 37 and 95 cycles. The concrete prepared with crushed dolomite fine and coarse aggregates, but also failed between 37 and 95 cycles. Three out of four of the specimens containing the treated cement showed greater resistance to weathering than companion specimens made with untreated cement. The four columns molded with absorptive form lining did not show any outstanding results attributable to this feature.

(b) The natural sand and gravel aggregates from Grenadier Island and Malone produced concrete of very low resistance to freezing and thawing tests. Concrete made with dolomite fine and coarse aggregate was found to be much more resistant to this type of test (See Table XI and XII). This was also true for concrete made with Owls Head sand in combinations with dolomite and limestone coarse aggregates. However, the results of the latter are not directly comparable because in order to approximate equal workability for all mixtures, the concrete made with natural sands contained 0.25 bbl. per cu.yd. less cement than the crushed sand mixtures. In all of the laboratory tests for concrete durability, it was found that the losses in flexural strength were in direct proportion to the reductions in modulus of elasticity, a fact which lends credence to the recently developed sonic modulus test for concrete specimens.

(c) The exposure tests at Massena (Tables XIV & XV), made especially to compare different fine aggregates in concrete, gave the following results:

(1) Of the eight mixtures containg the same coarse aggregate, the same cement content, and having the same slump, the one made with dolomite sand gave the highest beam strength both before and after 53 cycles of freezing and thawing.

(2) The average strengths for other mixtures compared to that of the dolomite sand concrete, the latter taken as the base, ranged from 0.70 to 0.89, for the specimens not subjected to freezing and thawing. Similar comparisons for the companion groups that were frozen and thawed (53 cycles)

showed strength ratios ranging from 0.67 to 0.88.

(3) Each of these eight mixtures showed a gain in flexural strength during the 43-day period while the freezing and thawing treatment was in progress. The amount of gain was 10.4 per cent for the dolomite sand specimens and ranged from 2.7 per cent to 14.7 per cent for the other groups in which different sands were used.

(4) The single group of specimens made with Owls Head gravel and sand exhibited the lowest strength both before and following the exposure treatment. It was the only group which showed a loss in strength. As compared with the beams made of dolomite fine and coarse aggregates, these specimens gave strength ratios of 0.60 at 28 days (without freezing), and 0.51 at the age of 71 days following the 53 cycles of freezing and thawing. The lower 28-day strength of the Owls Head gravel concrete, and the small retrogression in strength attributable to the effects of freezing and thawing, were indication that this aggregate was in some measure inferior to the crushed dolomite.

(5) These tests were discontinued on February 25, 1942, because of a change in weather conditions and a lack of freezing temperature. As a result, the number of cycles of freezing and thawing obtained was insufficient for an adequate measure of the durability of the concrete. A greater number of cycles and more severe conditions of the tests probably would have shown greater difference among the several groups of specimens.

(d) The tests at the laboratory in which different aggregates were compared for their relative influence on mix economy, workability, strength, and density of the concrete, gave rather indecisive results. In retrospect it appeared that finer and more nearly equal gradations of the sands for the different mixtures would have been advantageous. It is possible that this would have permitted the used of equal cement factors for more, or perhaps all, of the aggregate combinations and thereby provided a better basis for the comparisons of concrete quality.

(e) From the results of all three of these concrete durability studies one significant fact was brought out and appears to warrant special mention. It was evident that the concrete in which all of the aggregate particles consisted of the same type of stone, or mineral, showed higher flexural strength and greater resistance to deterioration by freezing and thawing. It was true for the Lyon Mountain Syenite in the columns tested at Treat Island, Maine and also, in every instance, for the crushed dolomite fine and coarse aggregate mixtures. This observation conforms to the theory that uniformity in respect to physical properties, such as thermal coefficient and modulus of elasticity, in structural concrete is an important factor to consider in the selection of materials.

SUGGESTIONS FOR FURTHER INVESTIGATION

1. In the summary of field explorations, limited data were furnished on several aggregate deposits which were noted as requiring further investigation. By this it was meant that more information was needed regarding the quality, the quantity, or the distribution and accessability of the material within the deposit before definite advice could be given regarding its possibilities for use in producing acceptable concrete aggregate. It will be apparent, in each instance, what principal items of information are lacking from the field inspector's reports for individual deposits.

2. No further field exploration for locating possible sources of concrete aggregate is recommended. However, it is believed that large samples of aggregates from ten or more different sources will be needed for use in making concrete durability tests and aggregate gradation studies.

3. Any additional large deposits which may be reported within reasonable distance from the project should be inspected and sampled.

4. Concrete durability tests including freezing and thawing, sonic modulus and flexural strength should be made for a number of fine aggregates. Similar tests should be made to compare concretes containing different coarse aggregates, particularly, dolomite, limestone, and natural gravel.

5. A series of laboratory tests should be made to determine the relative effects of different gradation of crushed and natural aggregates on the economy and quality of concrete mixtures. It is believed that considerable advantage may be gained by determining the optimum practical gradation for a crushed stone fine aggregate and comparing it with natural sands on the basis of equal cement content in concrete.

TABLE I.--AGGREGATE DATA

Symbol	Origin	Nature	Grading-as used-in % Passing 2"	1½"	1"	3/4"	½"	3/8"	No.4	8	16	30	50	100	Spec. Grav.	Absorp.	Loss in $MgSO_4$ (1)
N-G	Northern Quarry	Crushed Dolomite	100.0	91.4	52.8	35.7	27.5	17.3	1.0	--	--	--	--	---	2.84	0.3	5.4
N-S	" "	"	-----	----	----	----	----	----	97.8	86.8	51.2	25.9	13.9	8.5	2.79	0.3	5.4
G-G	Grenadier Isle	Glacial Gravel	99.5	81.9	52.0	42.8	28.6	14.9	0.5	---	---	---	---	---	2.66	1.1	13.2
G-S	" "	Glacial Sand	-----	----	----	----	----	----	93.4	67.4	40.6	23.0	9.3	3.3	2.64	1.0	27.7
P-G	Paro Pit	Glacial Gravel	100.0	78.8	51.7	40.2	24.4	15.4	0.7	--	--	--	--	--	2.66	1.0	10.9
P-S	" "	Glacial Sand	-----	----	----	----	----	----	90.6	65.4	45.6	31.7	17.0	7.8	2.64	1.2	27.8
L-G	Lyon Mt.	Crushed Syenite	100.0	93.5	51.8	39.4	20.3	13.3	0.0	--	--	--	--	--	2.89	0.4	2.8
L-S	" "	"	-----	-----	---	----	----	----	94.4	88.8	65.3	42.6	14.1	2.3	2.94	0.2	2.8
M-G	Mille Roches (2)	Crushed Limestone	99.6	90.0	55.1	32.3	12.9	8.1	0.7	--	--	--	--	--	2.71	0.3	1.4
O-S	Owls Head (2)	Glacial Sand	----	----	---	----	---	---	98.5	86.3	67.7	41.5	12.7	3.3	2.67	0.5	9.7

(1) Loss in % after 10 cycles of Central Concrete Laboratory $MgSO_4$ test.

(2) Used in laboratory durability series only.

TABLE II.--AGGREGATE MINERAL COMPOSITION

Mineral	Aggregate									
	Dolomite		Limestone	Syenite		Glacial				
	Coarse	Fine	Coarse	Coarse	Fine	Grenadier		Paro		Owls Hd
	%	%	%	%	%	Coarse	Fine	Coarse	Fine	Fine
						%	%	%	%	%
Quartz	1	1	Tr	--	1	--	13	--	10	30
Quartzite	--	--	--	--	--	--	--	28	--	3
Sandstone	--	--	--	--	--	45	25	56	43	19
Granitic	--	--	--	--	--	22	7	3	2	37
Feldspar:										
Soda	--	--	--	--	--	--	4	--	2	--
Potash	Tr	Tr	Tr	--	10	--	6	--	3	6
Soda-lime	--	--	--	--	--	--	--	--	--	Tr
Syenite(1)	--	--	--	60	65	--	--	--	--	--
Gabbro	--	--	--	--	--	10	--	--	--	3
Gneiss	--	--	--	--	--	--	--	--	--	1
Schist	--	--	--	--	Tr	--	--	--	--	--
Basalt	--	--	--	34	9	--	--	--	--	--
Magnetite	--	--	--	Tr	Tr	--	--	--	--	--
Pyroxenite	--	--	--	6	14	--	--	--	--	--
Amphibole	--	--	--	--	--	--	Tr	--	--	--
Mica	--	--	--	--	Tr	--	Tr	--	--	--
Chlorite	--	--	--	--	Tr	--	--	--	--	--
Calcium Carbonate	--	--	98.5	--	--	6)		2)		--
Magnesium						)	44	)	33	
Carbonate	92	92		--	--	Tr)		--)		--
Argillaceous Limestone	--	--	--	--	--	13	--	--	--	--
Shale	--	--	1	--	--	--	Tr	8	7	1
Mudstone	--	--	--	--	--	4	--	3	--	--
Iron Oxide	Tr	Tr	Tr	--	--	--	--	--	--	--
Organic	Tr	Tr	Tr	--	--	--	Tr	--	Tr	Tr

(1)
Quartz syenite 20%
Augite " 40%

TABLE III a.--CEMENT CHEMICAL DATA

CONSTITUENTS	CEMENTS * STL-C-1 SS-C-206a	STL-C-2 SS-C-206a + Vinsol Resin
	Calculated Compounds	
C_3S	47.3%	51.2%
C_2S	29.9	26.6
C_3A	5.5	5.1
C_4AF	11.0	11.3
$CaSO_4$	2.1	2.0
	Major Oxides	
SiO_2	22.85%	22.65%
Al_2O_3	4.40	4.29
Fe_2O_3	3.63	3.71
CaO	63.68	64.10
MgO	1.37	1.37
SO_3	1.21	1.19
	Minor Oxides	
Mn_2O_3	0.06%	0.06%
P_2O_5	0.18	0.19
Na_2O	0.40	0.42
K_2O	0.21	0.16
	Other Constituents	
Free CaO	0.38%	0.46%
Ignition Loss	1.11	1.05
Insoluble Residue	0.08	0.09
Chloroform solubility	0.006	0.027 (V.R.)
	Special Tests	
Water Soluble Na_2O	0.02%	0.04%
Water Soluble K_2O	0.09%	0.11%
Alkalinity	3.5 cc	3.5 cc
Free Alkali	1.8 cc	2.0 cc
Sugar Test-End Point	3.0 cc	2.9 cc
Clear Point	3.0 cc	2.9 cc
Floc Test	2.01%	1.06%
	Ratios	
CaO Saturation	71.3	70.7
Al_2O_3/Fe_2O_3	1.21	1.16
SiO_2/R_2O_3	2.85	2.83
CaO/SiO_2	2.79	2.83
Colony's Ratio	2.54	2.58

* The above are the analyses for cements used in Series A & B only.

TABLE III b.--CEMENT PHYSICAL DATA

TEST	CEMENTS STL-C-1 (Plain)	CEMENTS STL-C-2 (Vinsol Resin)
200 Mesh Sieve-% Ret.	0.60	0.63
325 Mesh Sieve-% Pass	96.31	96.45
Surface Area-sq.cm/gm	1890.	1918.
Heat of Solution-cal/gm	597.28	606.21
Heat of Hydration - cal/gm, 7 day	58.9	68.4
Heat of Hydration- cal/gm, 28 day	80.3	83.2
Initial Set	4:05	5:00
Final Set	5:45	7:00
Penetrometer Drop 1 hr.	341	343
" " 3 hrs.	6	8
Soundness-Steam	OK	OK
Autoclave Expansion	+0.018	+0.026
Specific Gravity	3.164	3.162
% Flow	81.25	100.0
Normal Consistency	24.50	24.50
Tensile Strength, P.S.I.		
3 day	231	216
7 day	399	353
28 day	439	434
Compressive Strength		
1 day	448	410
3 day	1615	1382
7 day	3033	2675
14 day	4290	3692
28 day	5408	4191
Sulfate Expansion		
7 day 1:6 mortar	.028%	.013%
14 day 1:6 mortar	.142%	.022%

TABLE IV.--MIXTURE DATA
with
Plain & Vinsol Resin Cement
(maximum size coarse aggregate = 2 inches)

Aggregate Fine Coarse	Vinsol (1) Resin	Cement Content sacks/cu.yd.	W/C gal./sack	Slump in.	R.E (2) sec.	Proportions by weight	Bleeding %(3)
Crushed Syenite	0	5.75	6.0	2 1/2	5	1-2.67-1.98-1.97	7.9
Crushed Dolomite	0	5.50	6.0	2 1/2	7.5	1-2.56-1.06-3.19	6.5
Paro Glacial	0	4.75	6.0	2 1/2	10	1-2.70-2.52-2.52	4.5
Grenadier Glacial	0	4.75	6.0	2 1/2	9	1-2.71-2.53-2.53	5.8
Crushed Syenite	0.03%	5.75	5.75	2 1/2	6	1-2.69-1.99-1.99	4.9
Crushed Dolomite	"	5.50	5.75	2 1/2	8	1-2.59-1.08-3.22	5.0
Paro Glacial	"	4.75	5.60	2 1/2	7	1-2.74-2.57-2.57	3.3
Grenadier Glacial	"	4.75	5.60	2 1/2	8	1-2.74-2.56-2.57	3.8

(1) By weight of the cement.

(2) Remolding effort in seconds.

(3) In terms of weight of original water content.

TABLE V.--MIXTURE DATA

Relative Water Demand
Plain Cement
(Maximum size coarse aggregate= 1 1/4 in.)

Aggregate Fine	Aggregate Coarse	W/C Gal/sack	Cement Content sacks/cu.yd.	Slump in.	R.E.(1) sec.	Proportions by Weight
P-S	P-G	5.5	5.5	2 3/4	11.5	1-2.47-2.02-2.03
G-S	G-G	5.5	5.5	2 1/2	12	1-2.47-2.02-2.04
O-S	N-G	6.0	5.5	2 1/2	28	1-2.39-0.87-3.46
O-S	M-G	6.0	5.5	2 1/2	20	1-2.39-2.15-2.15
N-S	N-G	6.0	5.75	2 3/4	18	1-2.54-0.77-3.10
N-S	M-G	6.0	5.75	2 1/2	19	1-2.54-1.92-1.92

(1) Remolding effort in seconds.

TABLE VI -Compressive Strength of Concrete
6" by 12" Cylinders

Aggregate Fine	Aggregate Coarse	Vinsol Resin by wt. of cement	Type of Forms	W/C g.p.s.	C.F. sacks/cu.yd	Compressive Strength in p.s.i. 7 day	14 day	28 day	90 day
Crushed	Syenite	0	Steel	6.0	5.75	2200	3660	3815	4210
"	"	0	Absorp.	6.0	5.75	4260	4950	5850	6300
"	"	0.03%	Steel	5.75	5.75	2760	3550	4430	5035
"	"	0.03%	Absorp.	5.75	5.75	4675	5375	6145	6750
Crushed	Dolomite	0	Steel	6.0	5.5	3025	3810	4615	5580
"	"	0	Absorp.	6.0	5.5	4770	5205	6015	6540
"	"	0.03%	Steel	5.75	5.5	3670	4160	4990	5700
"	"	0.03%	Absorp.	5.75	5.5	5200	5420	6335	6935
Grenadier	Glacial	0	Steel	6.0	4.75	2335	2770	3645	4413
"	"	0	Absorp.	6.0	4.75	2670	4430	4770	5500
"	"	0.03%	Steel	5.6	4.75	2350	2800	3810	4[illegible]60
"	"	0.03%	Absorp.	5.6	4.75	3275	3920	4300	5650
Paro	Glacial	0	Steel	6.0	4.75	2860	3470	4220	5110
"	"	0	Absorp.	6.0	4.75	4580	5065	6240	7310
"	"	0.03%	Steel	5.6	4.75	2550	3415	3970	4895
" "	"	0.03%	Absorp.	5.6	4.75	4145	4750	5540	----

TABLE VII.--FLEXURAL STRENGTH OF CONCRETE
6" by 6" by 48" Column Specimens

Aggregate Fine	Aggregate Coarse	Vinsol Resin by wt. of cement	Lining type	W/C g.p.s.	C.F. sax/cu.yd.	Flexural(1) Strength p.s.i.
Crushed	Syenite	0	Steel	6.0	5.75	630
"	"	0.03%	"	5.75	5.75	675
Crushed	Dolomite	0	"	6.0	5.5	840
"	"	0.03%	"	5.75	5.5	820
Grenadier	Glacial	0	"	6.0	4.75	610
"	"	0.03%	"	5.6	4.75	520
Paro	Glacial	0	"	6.0	4.75	540
"	"	0.03%	"	5.6	4.75	575

(1) At 28 days.

TABLE VIII--DENSITY DATA

6" by 6" by 48" Columns

Aggregate	Location on Column	Absorption 48 hr.	Absorption Ultimate	Absorption Average	Specific Gravity Bulk	Specific Gravity Av. Blk.	Specific Gravity Absolute	Specific Gravity Av. Abs.	% Voids	Av.	Unit Wt.	Av. U. W.
Paro	Top.	4.6	5.0		2.38		2.67		10.9		149	
"	Bot.	4.6	5.0	5.00	2.38	2.38	2.67	2.67	10.9	10.9	149	149
" + V.R.	Top	4.6	4.9		2.38		2.68		11.8		148.5	
" + V.R.	Bot.	4.5	5.0	4.95	2.36	2.37	2.64	2.66	11.6	11.7	147.5	148
Dolomite	Top	4.7	4.9		2.47		2.79		11.6		154	
"	Bot.	4.8	5.1	5.00	2.47	2.47	2.79	2.79	11.8	11.7	154	154
Dol. + V.R.	Top	4.7	4.8		2.43		2.77		12.1		152	
" + V.R.	Bot.	5.0	5.1	4.95	2.43	2.43	2.75	2.76	11.9	12.0	152	152
Grenadier	Top	5.8	5.9		2.33		2.67		12.5		146	
"	Bot.	5.4	5.6	5.75	2.33	2.33	2.67	2.67	12.7	12.6	146	146
Gren. + V.R.	Top	5.0	5.3		2.36		2.67		12.6		145.5	
" + V.R.	Bot.	5.2	5.5	5.40	2.34	2.35	2.67	2.67	12.4	12.5	146.5	146
Syenite	Top	5.6	6.2		2.48		2.89		13.9		156	
"	Bot.	4.5	5.2	5.7	2.56	2.52	2.89	2.89	11.4	12.7	160	158
Sy. + V.R.	Top	4.6	5.4		2.53		2.88		11.8		158	
" + V.R.	Bot.	4.6	5.6	5.5	2.55	2.54	2.88	2.88	11.5	11.7	158	158

TABLE IX.--MODULUS OF ELASTICITY

ST. LAWRENCE ALKALI BEAMS

Specimen Number	30 Days E-p.s.i. $x10^{-6}$	180 Days E-p.s.i. $x10^{-6}$	Relative E%
Paro PA-1	5.60	5.77	103
Dolomite NA-1	6.77	7.21	106
Grenadier GA-1	5.27	5.77	109
Syenite LA-1	6.06	6.41	106

TABLE Xa. --THERMAL DATA

Thermal coefficient of diffusivity

(Each value is the average of 4 runs).

Aggregate Fine Coarse	Diffusion constant in ft. 2/hr. Plain cement	Vinsol Resin Cement
Paro glacial	0.055	0.054
Dolomite	0.048	0.050
Grenadier glacial	0.050	0.041
Syenite	0.042	0.031

TABLE X b.--Thermal Expansion Data

No.	Description		Coeff. of thermal exp. Heating -20° to 60° C.	$\times 10^{-6}$ Cooling 60° to 0°
	Separate Minerals in Glacial Aggregate			
2-1	White or milky quartz		13.5	13.8
2-2	Yellowish quartz		11.8	11.7
2-3	Colorless quartz		11.7	12.4
2-4	Red granite	-25° to 2°C 6.6; 2° to 60° C. 5.6	6.0	2.8
2-5	Qrkosic quartzite		7.0	7.5
2-6	Chlorite schist		6.7	7.5
2-7	Quartzite		12.2	12.8
	Lyon Mountain Stone			
3-1	Quartz syenite		6.7	7.7
3-2	Augite "		5.3	6.1
$3\text{-}3_1$	Basalt		6.7	6.7
$3\text{-}3_2$	"		7.0	-
3-4	Diabase	-25 to 5.5°C, 9.1 5.5 to 9.5°C, -7.5 10 to 60°C, 6.5	7.0	7.7
4-1	Dolomite	-25 to 4°C 7.4 4 to 7°C -5.7 8 to 60°C 6.4	6.6	8.1

TABLE XI.--CR - STL - SERIES

FREEZING AND THAWING TEST - CONCRETE BEAMS

Northern Quarries Crushed Dolomite-Coarse & Fine Aggregate

Specimen Number	Initial E	3 cycles E*	3 cycles Rel. E-%	6 cycles E	6 cycles Rel. E-%	10 cycles E	10 cycles Rel. E-%	25 cycles E	25 cycles Rel. E-%	50 cycles E	50 cycles Rel. E-%	70 cycles E	70 cycles Rel. E-%	100 cycles E	100 cycles Rel. E-%	115 cycles E	115 cycles Rel. E-%	130 cycles E	130 cycles Rel. E-%
Control Average	7.31	7.41	102	7.43	102	7.48	102	7.56	103	7.71	105	7.74	106	7.77	107	7.86	108	7.86	108
Test (N-3A	7.22	6.84	93	6.77	92	6.77	92	6.84	92	6.84	90	6.97	91	6.97	91	6.97	90	6.84	88
Test (N-5A	7.22	6.97	95	6.97	95	6.97	95	6.97	94	6.97	92	6.97	91	--	--	---	--	---	--
Test (N-6A	7.34	6.97	93	6.84	91	6.84	91	6.97	92	6.97	90	7.02	90	7.02	90	7.02	89	7.02	89

Coarse Aggregate: Mille Roches Crushed Limestone
Fine Aggregate : Northern Quarries Crushed Dolomite

Specimen Number	Initial E	3 cycles E*	3 cycles Rel. E-%	6 cycles E	6 cycles Rel. E-%	10 cycles E	10 cycles Rel. E-%	25 cycles E	25 cycles Rel. E-%	50 cycles E	50 cycles Rel. E-%	70 cycles E	70 cycles Rel. E-%	100 cycles E	100 cycles Rel. E-%	115 cycles E	115 cycles Rel. E-%	130 cycles E	130 cycles Rel. E-%
Control Average	6.79	6.79	100	6.92	102	6.88	101	7.00	103	7.07	104	7.24	106	7.38	107	7.54	107	7.54	107
Test (MN-2	6.97	6.41	92	6.47	91	6.47	92	6.17	86	5.71	79	4.95	67	3.15	42	--	--	--	--
Test (MN-3	6.97	6.59	95	6.59	93	6.41	91	6.47	90	6.17	86	5.60	75	--	--	--	--	--	--
Test (MN-5	6.84	6.41	92	6.41	90	6.41	91	6.41	91	6.41	90	6.41	89	6.17	84	5.54	76	2.02	28

Coarse Aggregate: Mille Roches Crushed Limestone
Fine Aggregate : Owls Head Glacial Sand

Specimen Number	Initial E	3 cycles E*	3 cycles Rel. E-%	6 cycles E	6 cycles Rel. E-%	10 cycles E	10 cycles Rel. E-%	25 cycles E	25 cycles Rel. E-%	50 cycles E	50 cycles Rel. E-%	70 cycles E	70 cycles Rel. E-%	100 cycles E	100 cycles Rel. E-%	115 cycles E	115 cycles Rel. E-%	130 cycles E	130 cycles Rel. E-%
Control Average	6.55	6.57	100	6.63	101	6.59	101	6.71	103	6.82	104	6.86	105	6.90	106	6.90	106	6.93	107
Test (MO-3	6.29	5.84	93	5.77	91	5.82	91	5.77	89	5.77	88	5.77	88	5.71	86	5.71	86	5.66	84
Test (MO-5	6.29	5.77	92	5.77	91	5.71	90	5.71	88	5.71	87	5.71	87	--	--	--	--	--	--
Test (MO-6	6.34	5.84	92	5.82	91	5.33	83	5.82	89	5.82	88	5.71	86	5.71	85	5.71	85	5.71	84

* Note: E = Young's modulus of elasticity in lbs. per sq. in x 10^6 computed on basis of assumed density 148 #/cu. ft.

Relative modulus of elasticity for each test specimen (in %) computed on basis of 100% average control.

TABLE XI (Cont'd)

Coarse Aggregate: Northern Quarries Crushed Dolomite
Fine Aggregate : Owls Head Glacial Sand

	Specimen Number	Initial	3 cycles		6 cycles		10 cycles		25 cycles		50 cycles		70 cycles		100 cycles		115 cycles		130 cycles	
		E	E*	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel E-%
Control	Average	6.81	6.83	100	6.87	101	6.91	101	6.99	103	7.16	105	7.20	106	7.33	108	7.38	108	7.38	108
	(NO-1	7.15	6.47	91	6.41	89	6.47	90	6.34	86	6.47	87	6.47	86	6.17	80	6.17	80	6.06	79
Test	(NO-5	7.15	6.41	90	6.41	89	6.29	87	5.66	77	5.54	73	2.90	39	2.88	37	1.72	22	1.69	22
	(NO-6	7.02	6.41	91	6.41	90	6.41	90	6.34	87	6.34	86	6.34	85	6.29	83	6.12	81	6.12	81

Coarse Aggregate: Grenadier Island Glacial Gravel
Fine Aggregate: Grenadier Island Glacial Sand

	Specimen Number	Initial	3 cycles		6 cycles		10 cycles		25 cycles		50 cycles		70 cycles		100 cycles		115 cycles		130 cycles	
		E	E*	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel E-%
Control	Average	5.59	5.53	99	5.58	100	5.58	100	--	--	--	--	--	--	--	--	--	--	--	--
	(G-1	5.71	3.72	66	3.02	53	2.71	47	--	--	--	--	--	--	--	--	--	--	--	--
Test	(G-5	5.71	4.05	72	3.40	60	3.28	57	--	--	--	--	--	--	--	--	--	--	--	--
	(G-6	5.85	3.54	62	2.94	50	3.11	54	--	--	--	--	--	--	--	--	--	--	--	--

Coarse Aggregate: Paro Pit Glacial Gravel
Fine Aggregate : Paro Pit Glacial Sand

	Specimen Number	Initial	3 cycles		6 cycles		10 cycles		25 cycles		50 cycles		70 cycles		100 cycles		115 cycles		130 cycles	
		E	E*	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel. E-%	E	Rel E-%
Control	Average	5.98	5.88	98	5.89	98	5.92	99	--	--	--	--	--	--	--	--	--	--	--	--
	(P-2	5-85	3.11	54	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Test	(P-3	5-77	3.19	56	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	(P-5	6-12	--	--	--	--	4.89	81	3.03	50	2.96	48	2.86	47	1.54	25	1.51	25	--	--
	(P-6	5-85	--	--	4.69	82	4.79	83	4.58	78	4.64	79	4.64	79	4.09	70	3.72	64	3.36	58

* See Page 1 for foot notes.

TABLE XII.--CR-STL SERIES

EFFECT OF FREEZING & THAWING UPON FLEXURAL STRENGTH

1	2		3	4	5	6		
Spec. No.	Aggregate Fine	Aggregate Coarse	Cycles F&T	Flexural Strength psi.	Control Flexural Strength psi. (1)	Strength Ratio 4/5** in %	Condition After Freezing and Thawing	Comments: Type of Failure in Flexure
N-5-A	Crushed Dolomite	Crushed Dolomite	70	1245	1530	81.5	Edges rounding, Slightly spalled	Sheared through coarse aggregate.
N-3-A	"	"	130	1105	1655	67		" " " "
N-6-A	"	"	130	1120	1402	80		" " " "
MN-3	Crushed Dolomite	Crushed Limestone	70	790	1480	53.5	Edges rounding. All specimens slightly spalled and cracked.	Sheared through coarse aggregate.
MN-2	"	"	100	255	1345	19.0		Slight evidence of failure of coarse aggregate.
MN-5	"	"	130	1000	1435	70.0		Sheared through coarse aggregate.
MO-5	Glacial Sand	Crushed Limestone	70	760	1065	71.5	Edges rounding and slightly spalled.	Sheared through coarse aggregate.
MO-3	"	"	130	775	1030	75		" " " "
MO-6	"	"	130	845	1245	68		" " " "
NO-1	Glacial Sand	Crushed Dolomite	130	945	1255	75.5	Edges rounding Slight spalling	Sheared through coarse aggregate.
NO-5	"	"	130	220	1285	17.0	NO-5 badly cracked.	* Specimen failed at a crack.
NO-6	"	"	130	880	1280	79.0		Sheared through coarse aggregate. Few aggregate sockets visible, indicating mortar failure.*

** Column 4 over column 5.

TABLE XII (cont'd)

1	2		3	4	5	6	Comments	
Spec.	Aggregate Fine	Aggregate Coarse	Cycles F&T	Flexural Strength psi.	Control Flexural Strength psi.	(1) Strength Ratio 4/5** in%	Condition After Freezing and Thawing	Type of Failure in Flexure
G-2	Glacial Sand	Glacial Gravel	12	235	935	25	Entire surface mapcracked. G-4 shows two distinct cracks.	Specimen failed at a crack. See footnote.*
G-3	"	"	12	385	895	43		" " " "
G-4	"	"	12	225	840	27		" " " "
P-2	Paro Sand	Gravel	12	725	1070	67.5	Entire surface map-cracked.	*
P-3	" "	"	12	760	890	85.5		*
P-5	" "	"	115	395	1070	37.0	Edges rounding. Corners spalling. P-5 shows popout on top face. Specimens cracked.	* Specimen failed at a crack. Slight evidence of coarse aggregate failure. Also breaking of bond between coarse aggregate and mortar.
P-6	" "	"	130	640	1070	60.0		Sheared through some coarse aggregate. Also breaking of bond between coarse aggregate and mortar. *

Note: (1) At equal age.

*P,2,3,5,6) The bond between the coarse aggregate and mortar appears to have been weakened. Introduced moisture
*G,2,3,4) may then have frozen between the coarse aggregate and mortar, and, expanding, may have loosened the bond.

** Column 4 over column 5.

TABLE XIII.--ST. LAWRENCE SPECIMENS - 6" x 6" x 48" CONCRETE COLUMNS

TREAT ISLAND EXPOSURE RACK - EASTPORT, MAINE

		Initial Data		Oct. 28, 1941		Dec. 17, 1941		Jan. 25, 1942		
Specimen	Date	Cycles	F.&T.=0	Cycles	F.&T.=2	Cycles	F.&T.=37	Cycles	F.&T.=95	Condition Jan. 25, 1942
Number	Installed	E**	Rel.E-%	E	Rel.E-%	E	Rel.E-%	E	Rel.E-%	
STL-PB*	1941 Oct.3	(1)5.37	100	5.36	100	5.68	106	(4)	(4)	Raveling progressive, 8" of top gone. 12" longitudinal crack in side face. Poor condition.
PC	"	(1)4.47	"	4.50	101	4.47	100	(4)	(4)	Completely disintegrated at 87 cycles, January 20, 1942.
PBV	"	(1)4.30	"	4.34	101	4.34	101	(4)	(4)	Raveling progressive. Severe crack through center of column. Several cracks on upper face. Side face near top of column, & 24" of middle section very badly raveled.
STL-NB*	"	(2)7.18	"	7.37	103	7.45	104	(4)	(4)	Spalling progressive. Top of column raveled. Several longitudinal cracks on upper face.
NC	"	(2)4.81	"	6.77	141	6.45	134	(4)	(4)	Raveling progressive. Entire column raveling badly & cracked throughout. Top & bottom gone. No reading.
NBV	"	(2)4.63	"	6.59	142	6.75	146	5.42	117	Spalling progressive. Upper face spalling moderately. Ends & body of specimen remain essentially intact.

(1) (2) (3) (4) See next page.
* Absorptive form lining.
P = Paro Aggregate
N = Northern Quarries Aggregate

G= Grenadier Island Aggregate
L= Lyon Mountain
V= Vinsol Resin Cement

TABLE XIII (Cont'd)

		Initial Data		Oct. 28, 1941		Dec. 17, 1941		Jan. 25, 1942		
Specimen	Date	Cycles F.&T.= 0		Cycles F.&T.= 8		Cycles F.&T.= 37		Cycles F.& T.= 95		Condition Jan. 25, 1942
Number	Installed	E**	Rel.E-%	E	Rel.E-%	E	Rel.E-%	E	Rel.E-%	
ST1 CB*	1941 Oct. 3	(1)5.03	100	4.93	98	4.98	99	(4)	(4)	No change in raveling, Upper face edge raveling slightly. Specimen cracked throughout, in two places 14" of top of column gone. Failure started on side face which showed honeycomb.
GC	"	(1)4.40	"	5.83	132	4.32	98	(4)	(4)	Raveling progressive. Top corners badly raveled. 30" of middle section raveled to a core 5" diameter. Bottom gone. Col. cracked.
GBV	"	(1)4.38	"	5.94	136	4.65	106	2.32	53	Raveling progressive. All edges & corners badly raveled. Underneath face shows three transverse cracks.
STL-LB*	"	(3)5.78	100	5.92	102	5.98	103	6.22	108	Edges on upper face raveling.
LC	"	(3)5.15	"	5.29	103	5.37	104	5.40	105	Raveling progressive. Upper face at both ends raveling moderately. All edges rounding
LCV	"	(2)5.21	"	5.49	105	5.63	108	5.74	110	Slight increase in spalling. Underneath face spalled slightly at both ends. Upper face edges rounding.

Note: *Absorptive form lining.
**E = Young's modulus of elasticity in lbs. per sq. in. x 10^6 computed on basis of following densities used:

(1) 148 lbs. per cu. ft.
(2) 153 " " " "
(3) 158 lbs. per cu. ft.
(4) Specimen would not respond to sonic vibrations.

TABLE XIV - SERIES "C" TEST DATA

Combinations of Aggregate	Concrete Mix Data										Flexural Strength — Average for 5 Specimens				
	Cement (Sks/cu. yd.)	W/C (gallons/sack)	% Sand in Aggregate	Sp. Gr. of Sand.	Sp. Gr. of C. Agg.	% Abs. Sand (as used)	% Abs. C. Agg. (as used)	Slump (inches)	Conc. Molding T.° F.	$MgSO_4$ loss of Sand (%)	28 days without F. & T. (lbs./sq. in.)	71 days, 53 cycles of F. & T. (lbs./sq. in.)	% Gain in Flex. Strength.	*Strength Ratio without F. & T.	* Strength Ratio After F. & T.
Premo S. - Dolo. C. A.	5.37	6.38	40	2.66	2.82	0.4	0.2	1½	50	16	754	860	+14.1	0.85	0.88
Hartford S. -" " "	5.37	6.38	40	2.66	2.82	0.4	0.2	2½	50	20	768	827	+ 7.7	0.87	0.85
Owls Head S.-" " "	5.37	6.38	40	2.66	2.82	0.4	0.2	2½	50	10	614	658	+ 7.2	0.70	0.67
Grenadier S.-" " "	5.37	6.38	40	2.66	2.82	0.4	0.2	1½	50	19	730	837	+14.7	0.83	0.86
Richmond S. -" " "	5.37	6.38	40	2.66	2.82	0.4	0.2	2	51	19	711	786	+10.5	0.81	0.81
Lowville S. -" " "	5.37	6.38	40	2.66	2.82	0.4	0.2	3	52	5	669	705	+ 5.4	0.76	0.72
Dolo. Sand -" " "	5.34	6.94	40	2.82	2.82	0.3	0.2	2	52	--	884	976	+10.4	1.00	1.00
Dolo. Tailings" " "	5.30	7.23	40	2.82	2.82	0.3	0.2	3/4	53	--	784	805	+ 2.7	0.89	0.83
Owls Head S. - Owls Head G.	5.38	6.12	40	2.66	2.66	0.3	0.0	3½	53	4	527	495	+ 6.1	0.60	0.51

* Strength compared with control (dolomite fine and coarse aggregate).

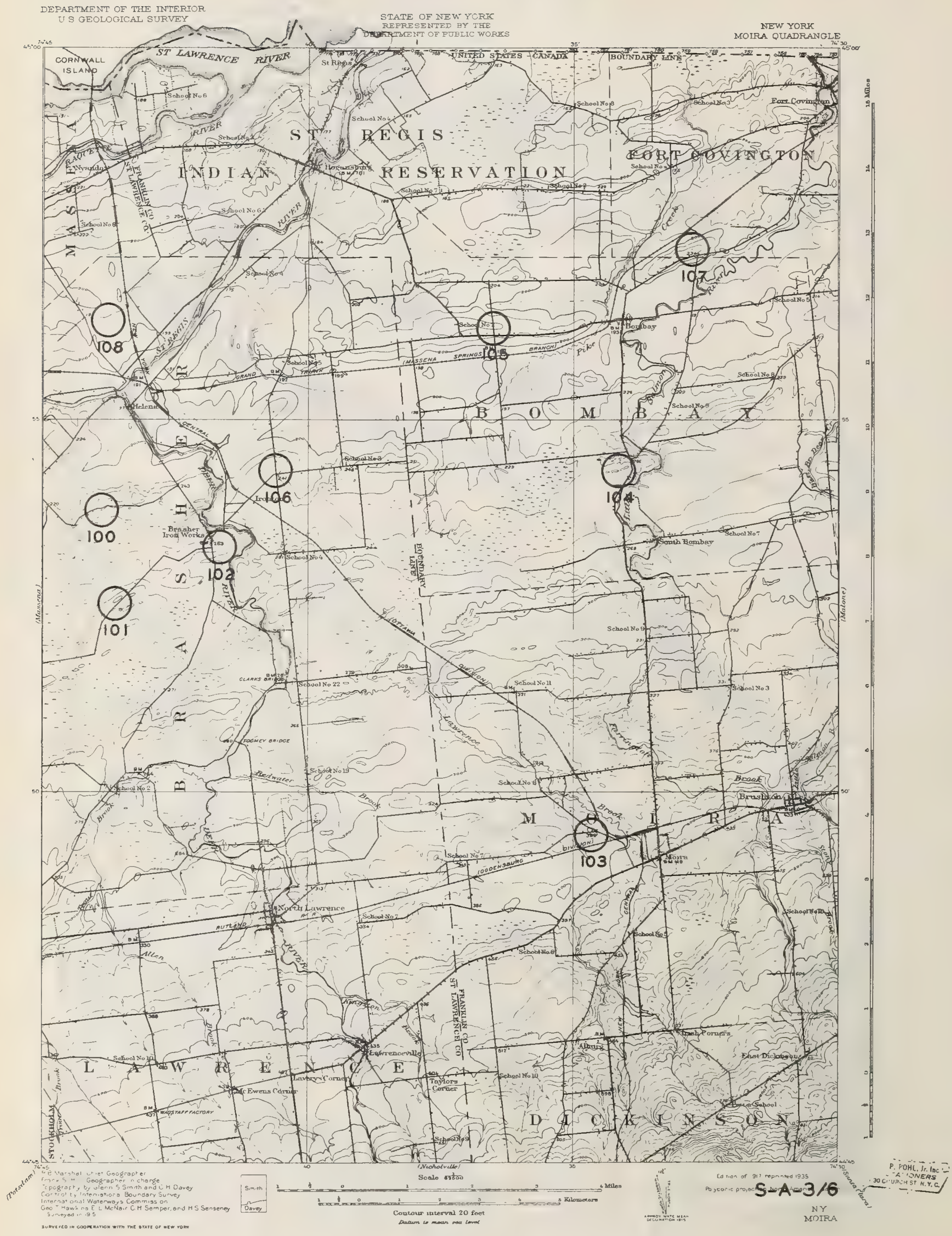
TABLE XV - SERIES "C" GRADATION OF AGGREGATES

Aggregate Sources	Coarse Agg. Sieve Size % Passing				Sand Sieve Size % Passing					
	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100
Premo Sand					98	87	73	50	19	4
Hartford Sand					95	77	59	40	20	4
Owls Head Sand					98	87	70	50	22	3
Grenadier Sand					97	77	59	45	22	6
Richmond Sand					98	90	69	47	16	4
Lowville Sand					98	90	73	39	19	3
Dolomite Sand					98	86	64	39	22	12
Dolomite Tailings					99	93	62	36	22	15
Owls Head Gravel	100	70	40	19	0					
Dolomite C. A.	100	68	50	13	0					

-63-

S-A-3/5

MASSENA


DEPARTMENT OF THE INTERIOR
U S GEOLOGICAL SURVEY
STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS
NEW YORK
MOIRA QUADRANGLE
CORNWALL ISLAND
ST LAWRENCE RIVER
UNITED STATES - CANADA
BOUNDARY LINE
St Regis
Fort Covington
ST REGIS
INDIAN RESERVATION
FORT COVINGTON
Hogansburg
Bombay
South Bombay
BOMBAY
Helena
Brasher Iron Works
BRASHER
Clarks Bridge
MASSENA SPRINGS BRANCH
GRAND TRUNK
OTTAWA DIVISION
RUTLAND R R
North Lawrence
MOIRA
Moira
Brushton
LAWRENCE
Lawrenceville
Lawrys Corner
McEwens Corner
Taylors Corner
Irish Corners
East Dickinson
Alburg
DICKINSON
STOCKHOLM
FRANKLIN CO
ST LAWRENCE CO
(Massena)
(Malone)
(Potsdam)
(Nicholville)
(Santa Clara)
108
105
107
106
104
100
102
101
103
Scale 1/62500
4 Miles
5 Kilometers
Contour interval 20 feet
Datum is mean sea level
Edition of 1917 reprinted 1935
S-A-3/6
N.Y.
MOIRA
SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK
P. POHL, Jr. Inc.
STATIONERS
30 CHURCH ST. N.Y.C.

S.E.D.

APR 1 1 1941

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS

NEW YORK
(FRANKLIN COUNTY)
MALONE QUADRANGLE

R B Marshall Chief Geographer
Frank Sutton Geographer in charge
Topography by Glenn S Smith and T F Slaughter
Control by International Boundary Survey E L McNair
C B Kendall, Geo T Hawkins H S Senseney
and A J Kavanagh
Surveyed in 1914-1915

SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK

Scale $\frac{1}{62500}$

Contour interval 20 feet
Datum is mean sea level

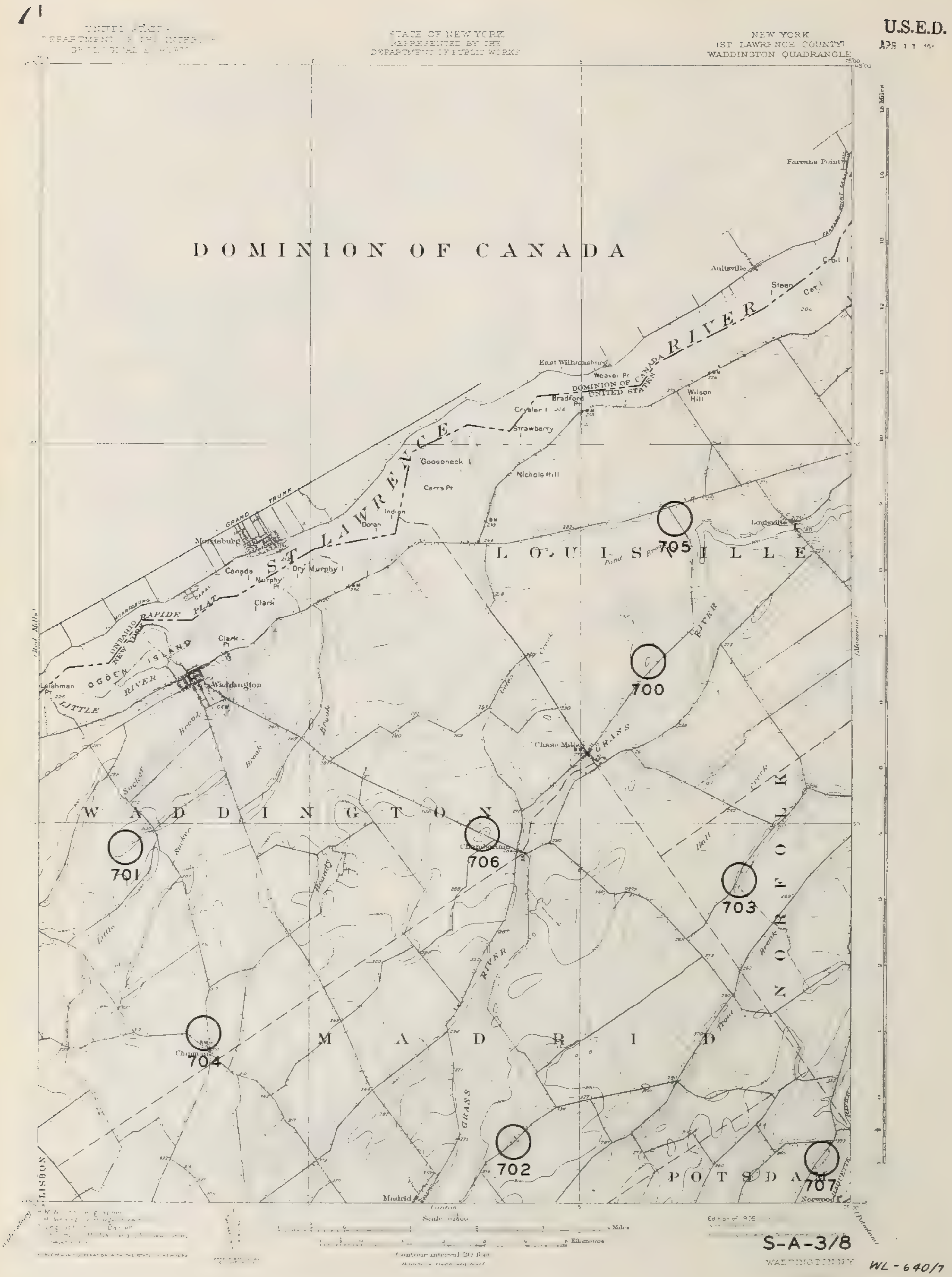
APPROXIMATE MEAN DECLINATION 1915

Edition of 1917 reprinted 1939
Polyconic projection North American datum

S-A-3/7

MALONE N.Y.

C-640/10


U.S.E.D.
STATE OF NEW YORK
NEW YORK
(ST LAWRENCE COUNTY)
WADDINGTON QUADRANGLE
DOMINION OF CANADA
ST. LAWRENCE RIVER
DOMINION OF CANADA
UNITED STATES
Farrans Point
Aultsville
Steen
East Williamsburg
Weaver Pt
Bradford Pt
Wilson Hill
Crysler I
Strawberry
Goosenack I
Nichols Hill
Carrs Pt
Indian
Doran
Morrisburg
GRAND TRUNK
Canada
Murphy Pt
Dry Murphy I
Clark
Clark Pt
RAPIDE PLAT
OGDEN ISLAND
LITTLE RIVER
Leishman Pt
Waddington
LOUISVILLE
Louisville
705
700
Chase Mills
GRASS
WADDINGTON
701
706
Chamberlains
703
NORFOLK
MADRID
704
Chamonix
702
707
POTSDAM
Madrid
Norwood
LISBON
Contour interval 20 feet
S-A-3/8
WL-640/7

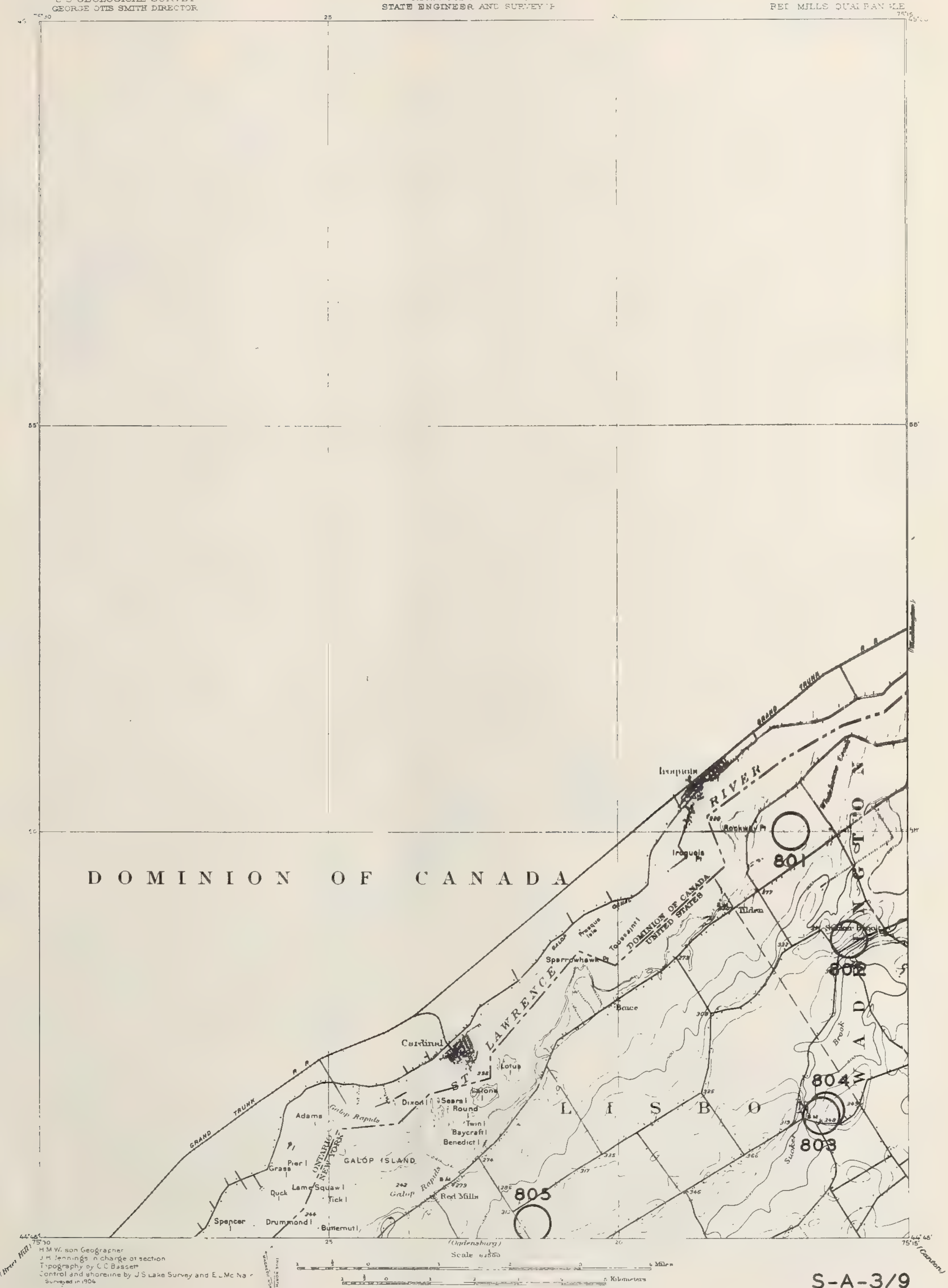
DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, SECRETARY
U S GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

TOPOGRAPHY

STATE OF NEW YORK
REPRESENTED BY THE
STATE ENGINEER AND SURVEYOR

NEW YORK
(ST LAWRENCE COUNTY)
RED MILLS QUADRANGLE

.E.D.
APR 11 1941



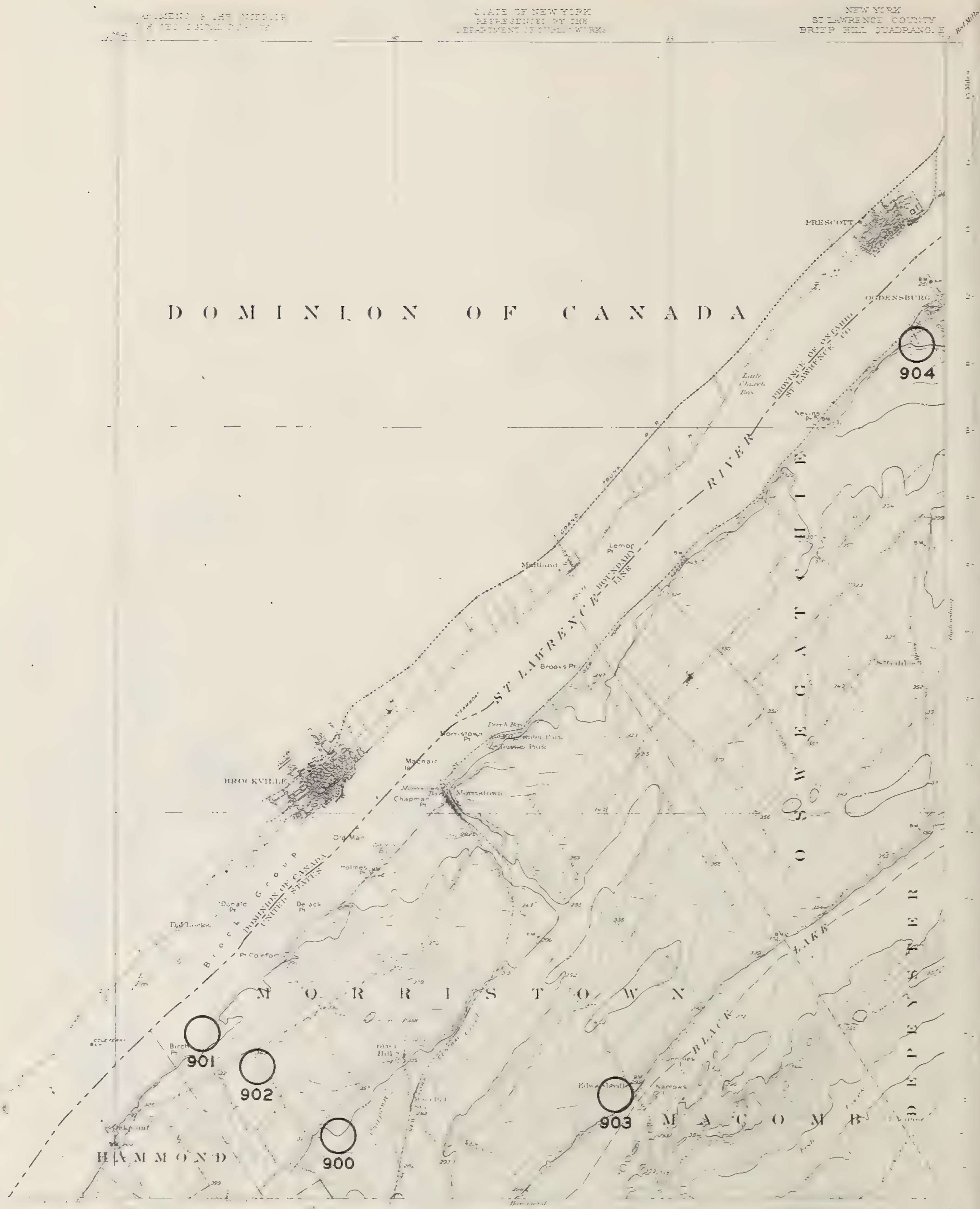
H.M. Wilson, Geographer
J.H. Jennings, in charge of section
Topography by C.C. Bassett
Control and shoreline by U.S. Lake Survey and E.L. McNair
Surveyed in 1904

SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK

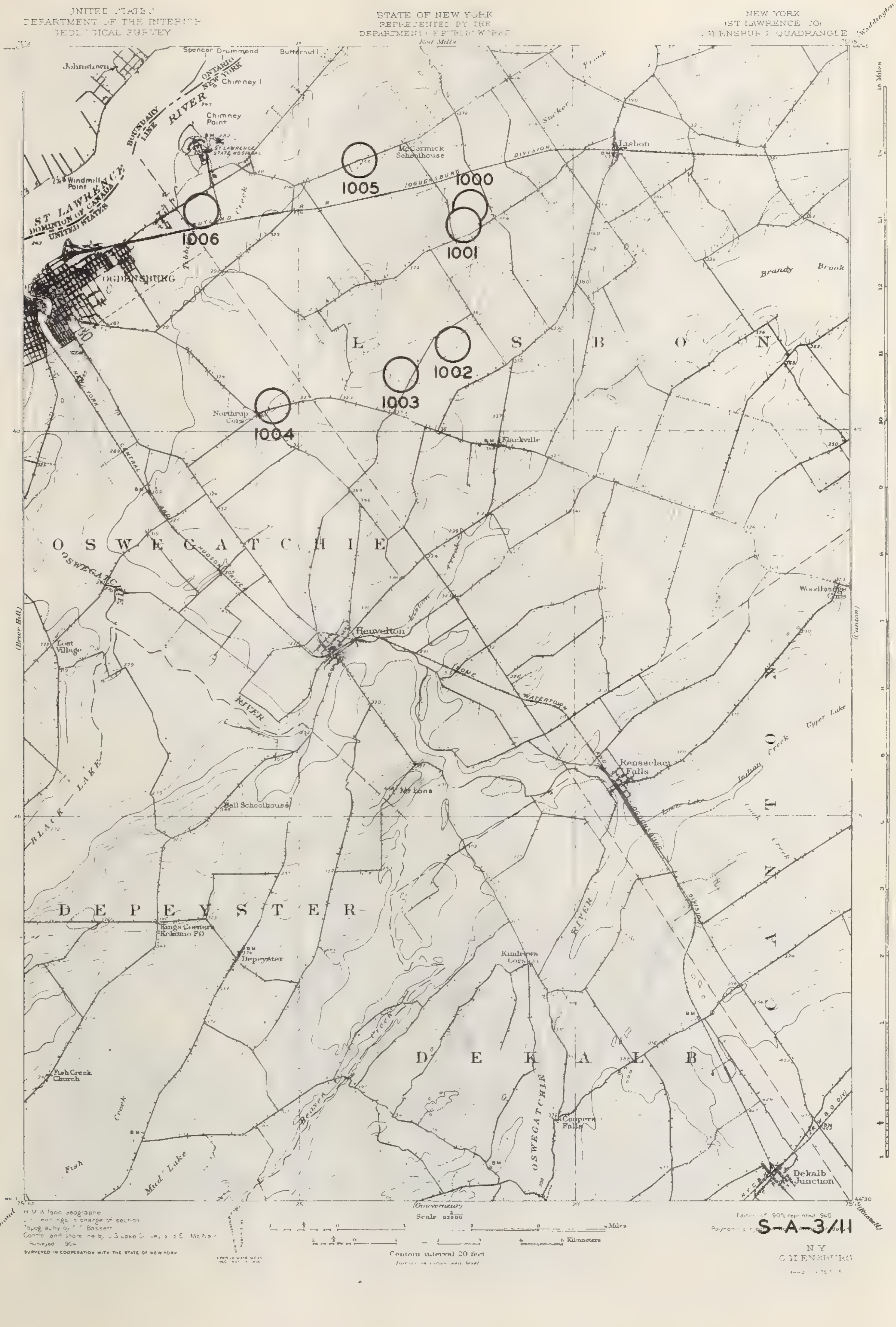
S-A-3/9

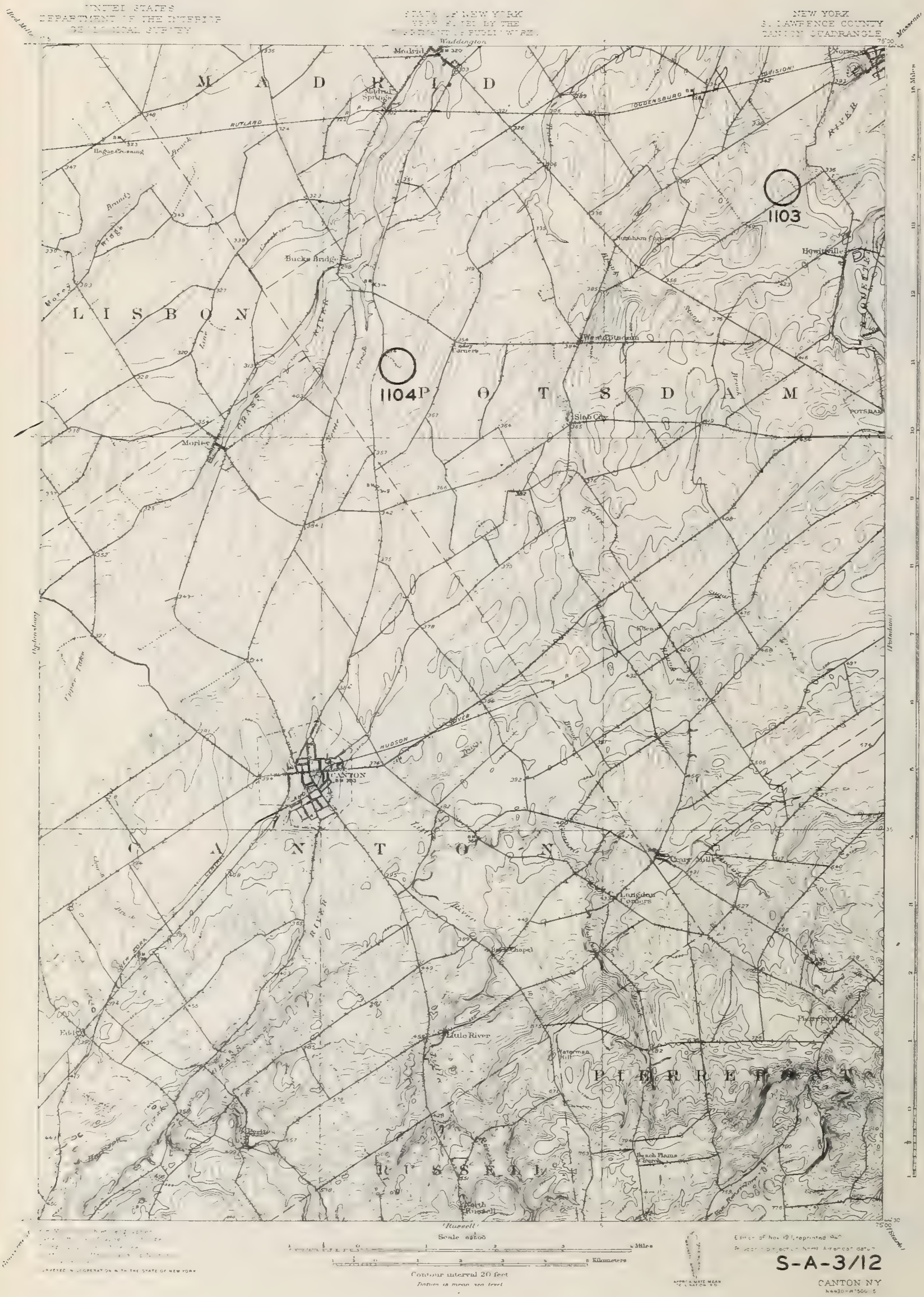
RED MILLS
Edition of 1906
reprinted 1921

GQ-64046


NEW YORK
ST LAWRENCE COUNTY
DOMINION OF CANADA
PRESCOTT
OGDENSBURG
904
Little Church Bay
PROVINCE OF ONTARIO
ST LAWRENCE CO
RIVER
ST LAWRENCE
BOUNDARY LINE
Maitland
Lemon Pt
Brooks Pt
Morristown Pt
Macnair Is
Chapman Pt
Morristown
BROCKVILLE
Old Man
Brock Group
DOMINION OF CANADA
UNITED STATES
Pt Comfort
MORRISTOWN
OSWEGATCHIE
BLACK LAKE
901
902
900
903
HAMMOND
MACOMB
Narrows

S-A-3/10


STATE OF NEW YORK
NEW YORK
1005
1000
1001
1006
1002
1003
1004
Johnstown
Spencer
Drummond
Chimney I
Chimney Point
Windmill Point
ST LAWRENCE
RIVER
BOUNDARY LINE
DOMINION OF CANADA
UNITED STATES
ONTARIO
NEW YORK
OGDENSBURG
McCormick Schoolhouse
Lisbon
Brandy Brook
L I S B O N
Northrup Cors
Flackville
O S W E G A T C H I E
Heuvelton
Lost Village
Rensselaer Falls
Mt Lona
Ball Schoolhouse
BLACK LAKE
D E P E Y S T E R
Kings Corners
Depeyster
D E K A L B
Fish Creek Church
Fish
Mud Lake
Coopers Falls
OSWEGATCHIE
Dekalb Junction
Upper Lake
Indian Creek
Scale
Contour interval 20 feet
S-A-3/11


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF NEW YORK
NEW YORK
ST. LAWRENCE COUNTY
CANTON QUADRANGLE
M A D R I D
L I S B O N
P O T S D A M
C A N T O N
P I E R R E P O N T
R U S S E L L
Madrid
Madrid Springs
Bucks Bridge
Morley
West Potsdam
Norfolk
Howitville
CANTON
Langdon Corners
Little River
Pierrepont
North Russell
Hague Crossing
Ogdensburg
Rutland
1103
1104
Scale 62500
Miles
Kilometers
Contour interval 20 feet
Datum is mean sea level
S-A-3/12
CANTON N.Y.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS

NEW YORK
(ST LAWRENCE COUNTY)
POTSDAM QUADRANGLE

H. M. Wilson Geographer
J. H. Jennings in charge of section
Topography by Chas. E. Cooke
Control by E. L. McNair and Glenn S. Smith
Surveyed in 1905-1906

SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK
Partly within Adirondack Park

APPROXIMATE MEAN DECLINATION 1906

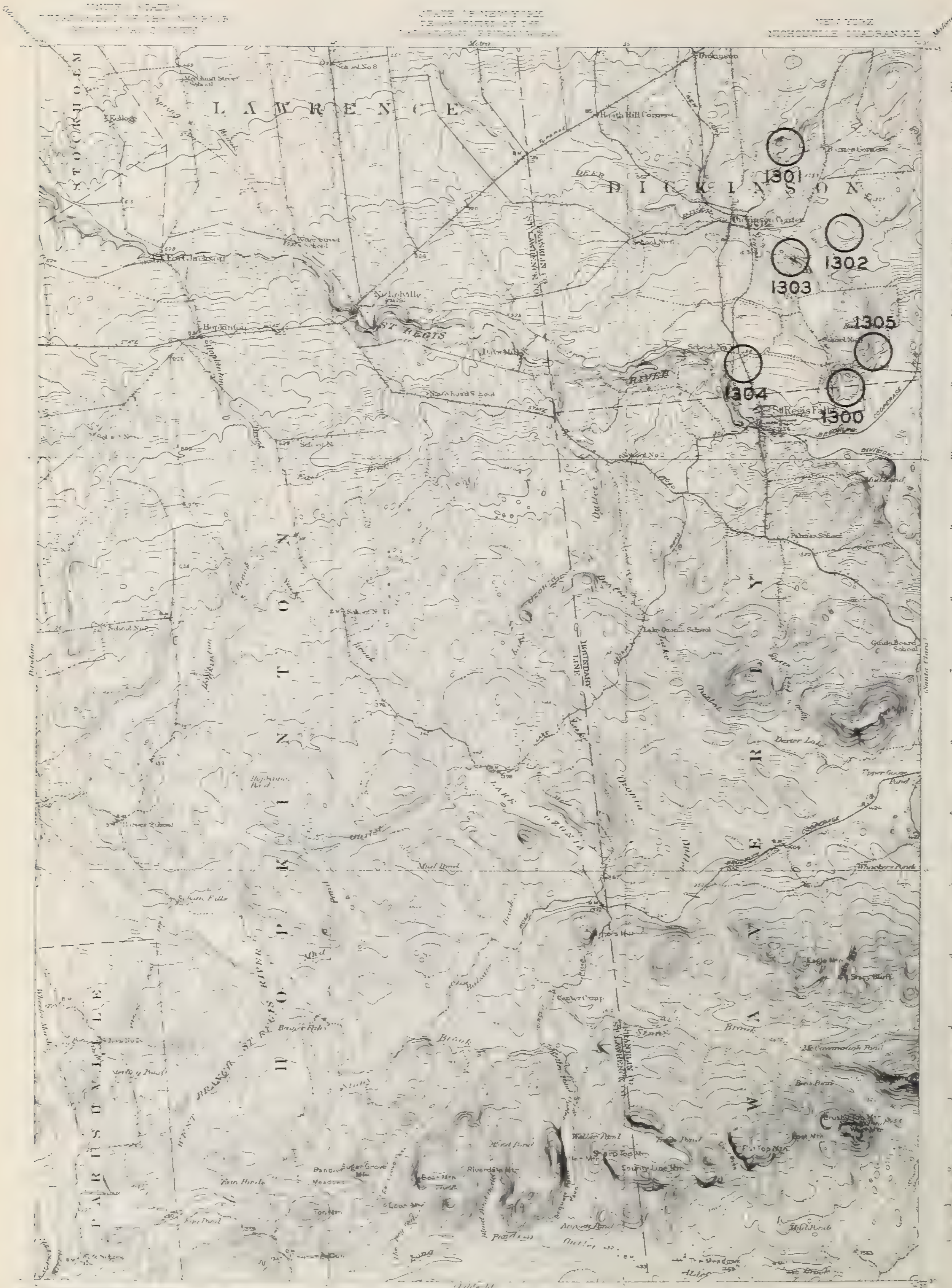
Scale 1/62500

Contour interval 20 feet
Datum is mean sea level

Edition of June 1908 reprinted 1940
Polyconic projection North American datum

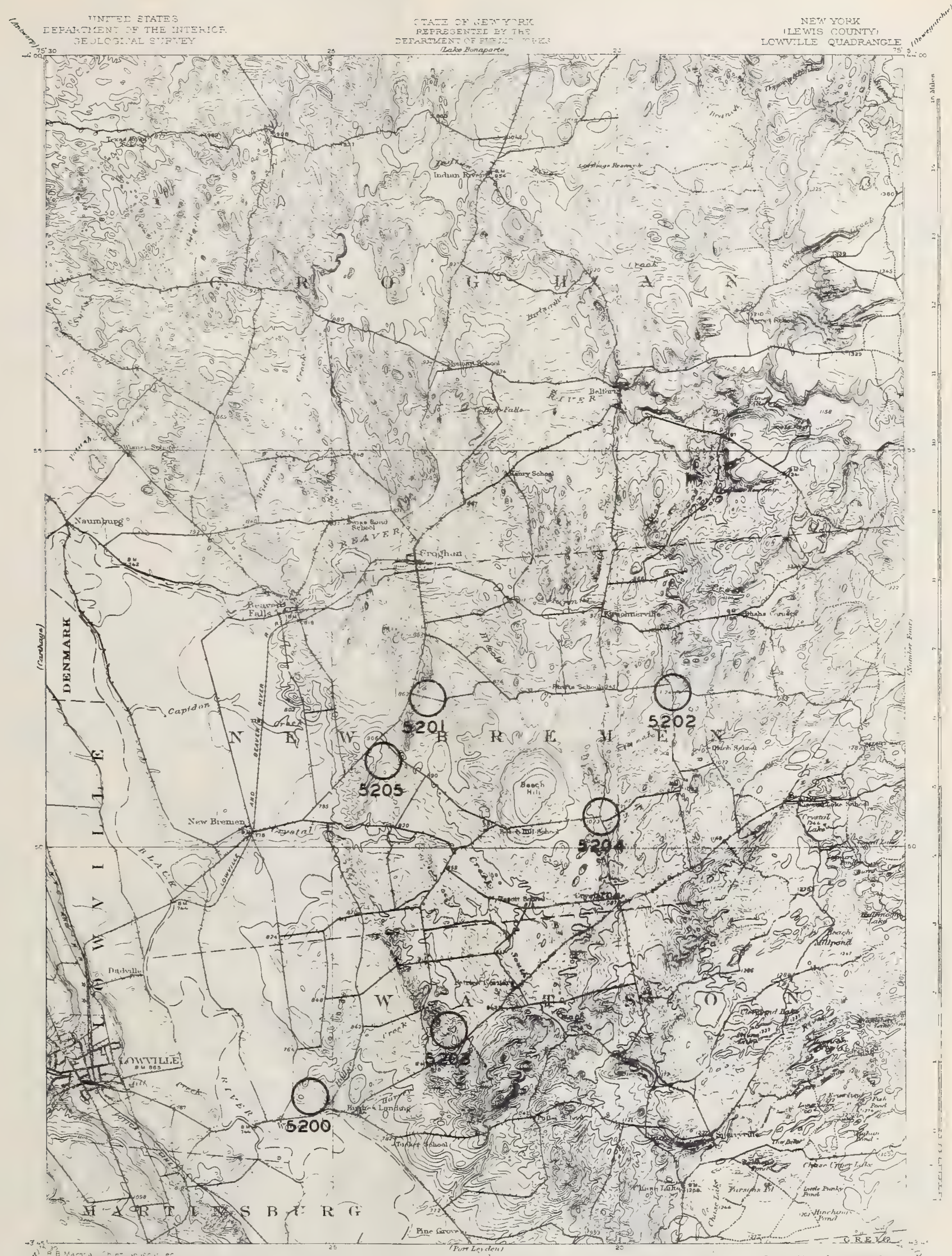
S-A-3/13

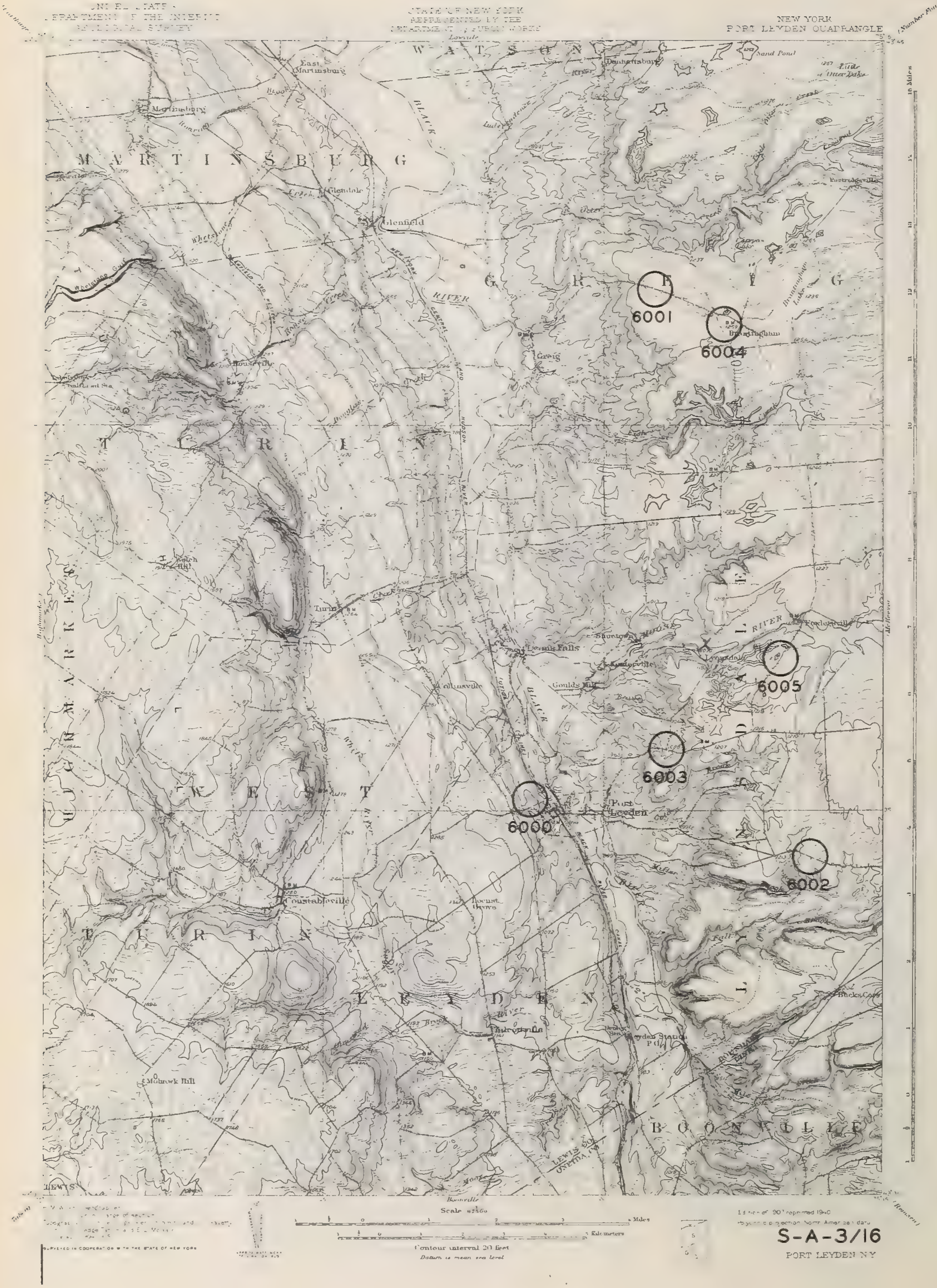
POTSDAM N.Y.



LAWRENCE
DICKINSON
HOPKINTON
WAVERLY
1300
1301
1302
1303
1304
1305
ST REGIS
RIVER
St Regis Falls
Dickinson Center
Nicholville
Fort Jackson
Hopkinton
Lake Ozonia
Dexter Lake
Palmer School
Eagle Mtn
Mud Pond

S-A-3/14


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS
NEW YORK
(LEWIS COUNTY)
LOWVILLE QUADRANGLE
(Lake Bonaparte)
C R O G H A N
N E W B R E M E N
W A T S O N
M A R T I N S B U R G
L O W V I L L E
DENMARK
(Carthage)
Indian River
Belfort
Naumburg
Croghan
Beaver Falls
New Bremen
Beech Hill
Dadville
LOWVILLE
Pine Grove
Crystal Lake
Chase Lake
Number Four
5200
5201
5202
5203
5204
5205
(Port Leyden)
Contour interval 20 feet
Datum is mean sea level
SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK
S-A-3/15
N.Y.
LOWVILLE


STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS
NEW YORK
PORT LEYDEN QUADRANGLE
WATSON
East Martinsburg
Martinsburg
MARTINSBURG
Glendale
Glenfield
Sand Pond
Houseville
GREIG
Greig
Brantingham
6001
6004
TURIN
Turin
Lyons Falls
Collinsville
Goulds Mill
Port Leyden
6005
6003
6000
6002
WEST TURIN
Constableville
LEYDEN
Leyden Station
Mohawk Hill
Bucks Corners
BOONVILLE
LEWIS
LEWIS CO.
ONEIDA CO.
Boonville
Scale $\frac{1}{62500}$
Miles
Kilometers
Contour interval 20 feet
Datum is mean sea level
Edition of 1907 reprinted 1940
S-A-3/16
PORT LEYDEN N.Y.

NATIONAL TOPOGRAPHIC SERIES

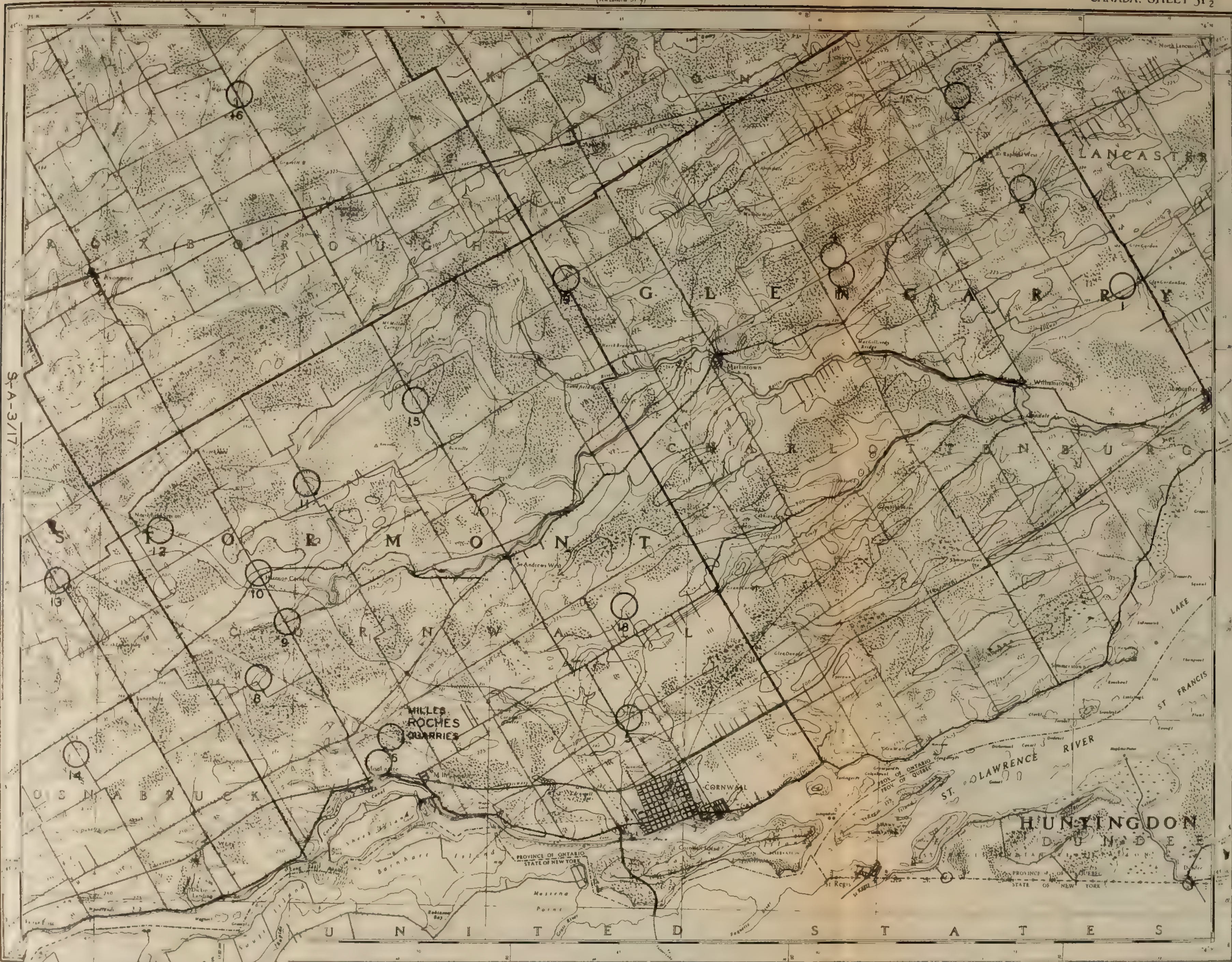
DEPARTMENT OF NATIONAL DEFENCE

GEOGRAPHICAL SECTION, GENERAL STAFF

(Alexandria 31 G/2)

CANADA, SHEET 31 G/2

U.S.E.D.
APR 14



CORNWALL

ONTARIO - QUEBEC

Scale: One Inch to One Mile = 1/63,360

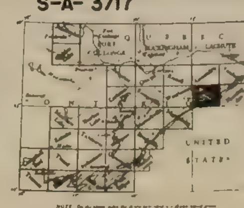
REFERENCE

Contour Interval 25 Feet

All Elevations in Feet above Mean Sea Level

REFERENCE

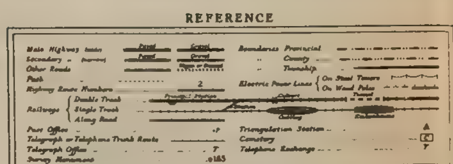
S-A- 3/17



LC-650/7

Surveyed and Reproduced by the Geographical Section, General Staff
DEPARTMENT OF NATIONAL DEFENCE.

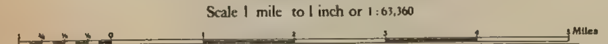
Original Survey 1906
Resurveyed 1938, with aerial photographs taken by R.C.A.F.
Reprinted 1940.
Magnetic Declination 15° 07′ W. at centre of sheet, 1939.



MORRISBURG

ONTARIO

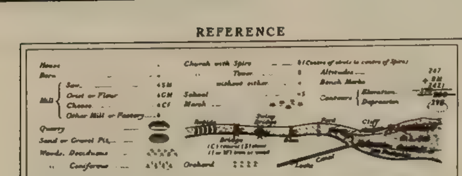
Scale 1 mile to 1 inch or 1:63,360

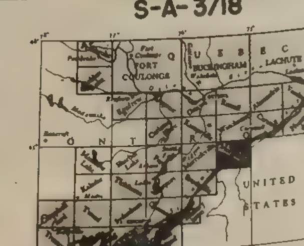


Contour interval 25 Feet

All Elevations in Feet above Mean Sea Level.

NOTE: Grid squares may be drawn on this map by joining the corresponding divisions shown along the outer border, this will provide a series of four mile squares which form a convenient system of reference. The numbers of the squares are also given along the outer border.





TOPOGRAPHIC MAP

CANADA 1 INCH TO 1 MILE

ONTARIO

WINCHESTER SHEET

SHEET Nº 31 G/3

S-A-3/19   ONTARIO 75 00 - 45 00

Highway Routes 31, etc.

Published by the Geographical Section General Staff
Department of National Defence 1909
Revised 1933

Magnetic Declination 0°38' W at Winchester Jan 1933
Polyconic Projection
Elevations in feet above Mean Sea Level
Surveyed in 1905 by the Geographical Section, G.S.

Provincial Boundary
County
Township
Railways: Single Track; Double; Railway on road
Cutting
Embankment
Road, Paved; Improved; Other; Wagon or Unused Road
Path
Canal and Locks
Bridges: Masonry; Steel or Iron; Wood
Swing Bridge (Steel or Wood)
Dam (Wood or Masonry)
Wagon Ford
Ferry
Cliff
Quarry
Sand or Gravel Pit

Scale 63360 or 1 Inch to 1 Mile

Miles 1 0 1 2 3 4 5 Miles

Yards 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 Yards

Contour interval 25 Feet

INDEX TO ADJOINING SHEETS

PRICE 25 CENTS

Railway Station
Post Office
Church: Without spire or tower; With; Centre of cross is centre of spire
Mill: Saw mill; Grist or Flour mill; Other mill or factory; Cheese Factory
School
Blacksmith shop or Garage
Hotel or tavern
House or Barn
Telegraph or Telephone Line
Telephone
Lighthouse
Cemetery
Triangulation Station
Altitudes
Bench Marks
Marsh
Woods (Deciduous) (Coniferous)
Contours (Elevation) (Depression)
Electric Power Lines on Steel Towers; Wood Poles

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE
GEOGRAPHICAL SECTION, GENERAL STAFF
(Kemptville $31\frac{G}{5}$)

CANADA, SHEET $31\frac{B}{13}$

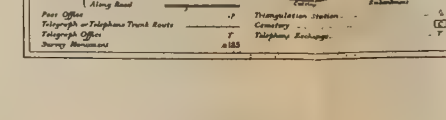
(Brockville $31\frac{B}{12}$)

S-A-3/20

Surveyed and Reproduced by the Geographical Section, General Staff.
DEPARTMENT OF NATIONAL DEFENCE.

Original Survey 1905.
Resurveyed 1938, with aerial photographs taken by R.C.A.F.
Reprinted 1940.
Magnetic Declination 1°55′W at centre of sheet, 1939.

REFERENCE



MERRICKVILLE

ONTARIO

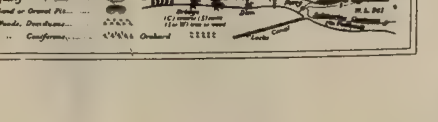
Scale 1 mile to 1 inch or 1:63,360

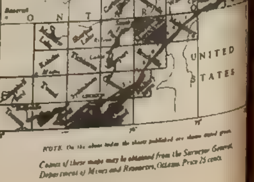
Miles
1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000 Yards

Contour interval 25 Feet
All Elevations in Feet above Mean Sea Level.

NOTE: Grid squares may be drawn on this map by joining the corresponding divisions shown along the outer border; this will provide a series of four mile squares which form a convenient system of reference. The numbers of the squares are also given along the outer border.

REFERENCE





NOTE. On the above index the sheets published are shown tinted green.
Copies of these maps may be obtained from the Surveyor General, Department of Mines and Resources, Ottawa. Price 25 cents.

NATIONAL TOPOGRAPHIC SERIES

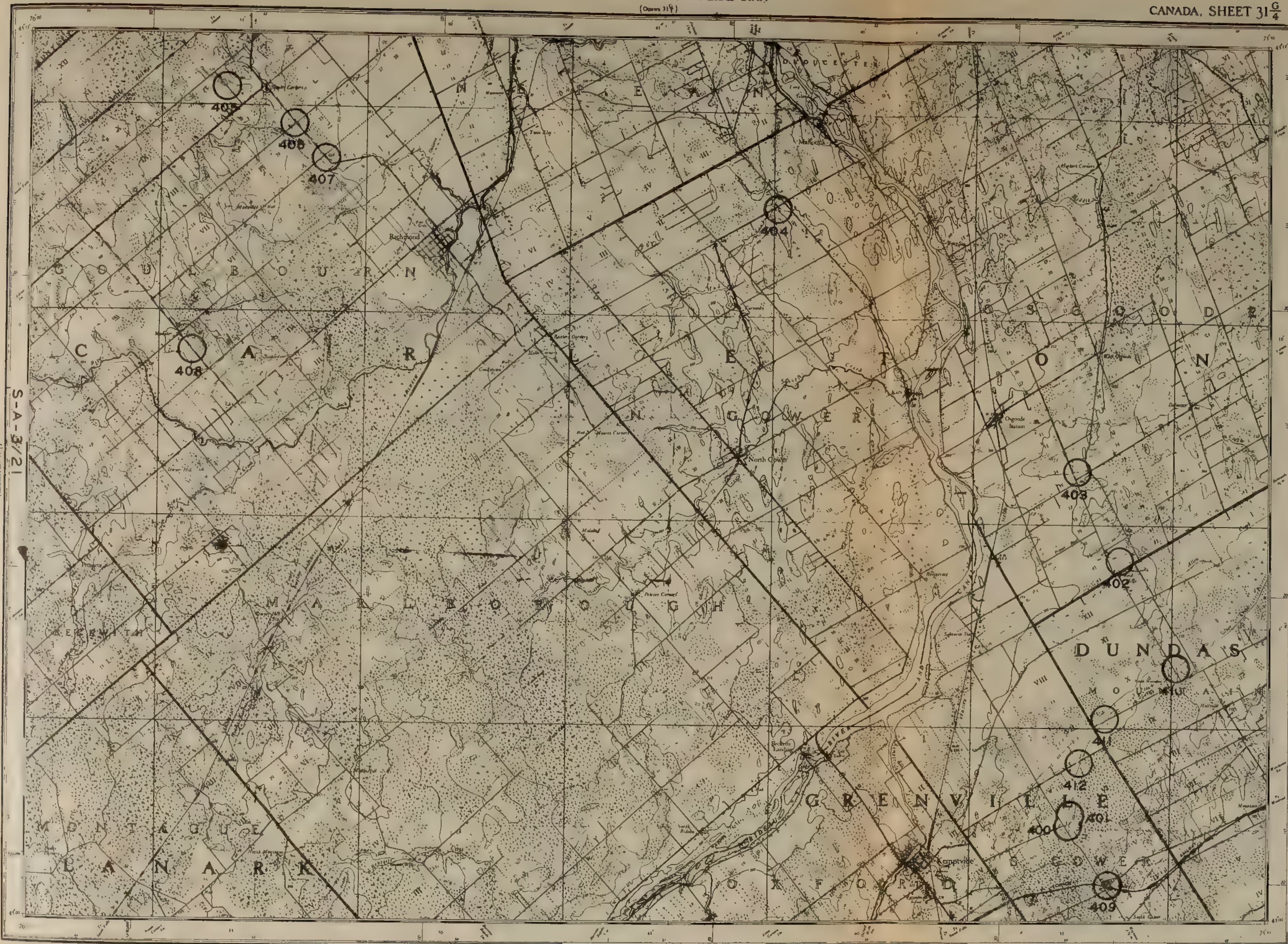
DEPARTMENT OF NATIONAL DEFENCE

HONOURABLE IAN A. MACKENZIE, P.C., M.A., LL.B., Minister

GEOGRAPHICAL SECTION, GENERAL STAFF

(Ottawa $31\frac{G}{5}$)

CANADA, SHEET $31\frac{G}{4}$

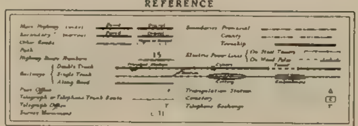


(Merrickville $31\frac{B}{11}$)

S-A-3/21

Surveyed and Reproduced by the Geographical Section, General Staff
DEPARTMENT OF NATIONAL DEFENCE
Original Survey 1906
Resurveyed 1934
Reprinted 1935
Magnetic Declination 13°05' W. at North Gower 1936

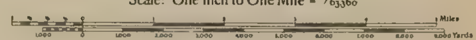
REFERENCE



KEMPTVILLE

ONTARIO

Scale: One Inch to One Mile = 1/63360

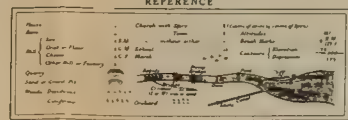


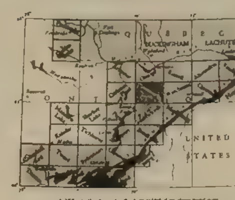
Contour Interval 25 Feet

All Elevations in Feet above Mean Sea Level

NOTE. The grid squares, four miles to a side, provide a ready method of referring to or locating features. Four squares are shown within the solid lines and only the even squares are numbered in the margin. The east and west sides of the squares are not true north and south lines but have a deflection to the east varying from due north on the west side of the map to 0°21' on the east side. Any square is identified by the numbers along the outer border, for example Munster will be found in square 14-171

REFERENCE





DEPARTMENT OF NATIONAL DEFENCE
GEOGRAPHICAL SECTION, GENERAL STAFF

NATIONAL TOPOGRAPHIC SERIES

CANADA, SHEET 31 G/5

S-A-3/22

Published by the Geographical Section, General Staff.
DEPARTMENT OF NATIONAL DEFENCE.
Reprinted 1940

OTTAWA

ONTARIO – QUEBEC

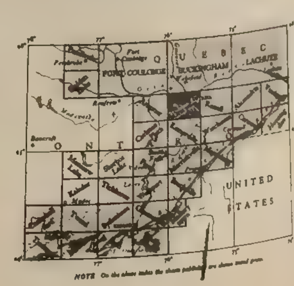
Scale 1 mile to 1 inch or 1: 63,360

Contour Interval 25 Feet.
All Elevations in Feet above Mean Sea Level.

REFERENCE

REFERENCE

Magnetic Declination, 14°01' W. near Dominion Observatory, 1935.
Surveyed by Geographical Section, G.S.
Original Survey 1923.
Revised 1936.



Copies of these maps may be obtained from the Surveyor General Department of Mines and Resources, Ottawa. Price 25 cents.

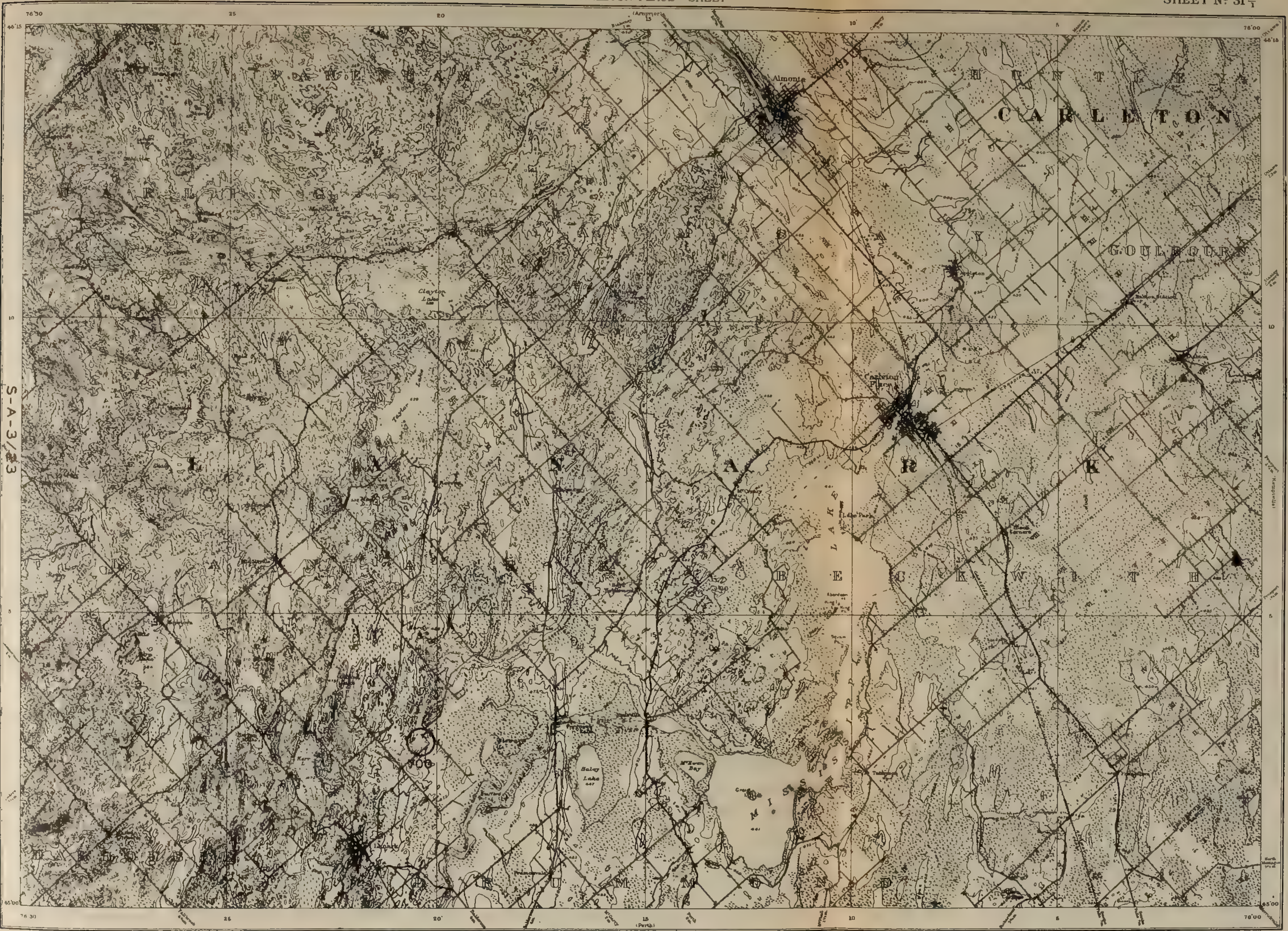
CANADA 1 INCH TO 1 MILE

TOPOGRAPHIC MAP

ONTARIO

CARLETON PLACE SHEET

SHEET Nº 31 F/1



S-A-3/23

ONTARIO 76°00'-45°00'

Highway Routes 15 etc

Published by the Geographical Section General Staff

Department of National Defence 1929

Reprinted 1939

Magnetic Declination 11°38' W at McCreary, Oct 1928 (Local attraction)

Polyconic Projection

Elevations in feet above Mean Sea Level

Surveyed in 1927 by the Geographical Section, G.S., with aid of aerial photos by the Royal Canadian Air Force

Scale 1/63,360 or 1 Inch to 1 Mile

Contour interval 25 Feet

PRICE 25 CENTS

TOPOGRAPHIC MAP

QUEBEC – ONTARIO

HUNTINGDON SHEET

CANADA 1 INCH TO 1 MILE

SHEET No 31 G/1

Published by the Geographical Section, General Staff.
Department of National Defence 1909.
Revised 1935

International Boundary and adjacent topography from International Boundary Commission

Magnetic Declination, 14°27' W. Huntingdon Dec. 1934.
Polyconic Projection
Elevations in Feet above Mean Sea Level.
Surveyed in 1907 by the Geographical Section, G.S.

S-A-3/24

ONTARIO – QUEBEC 74°00'-45°00'

Highway Routes 2, etc.

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE

HONOURABLE IAN A MACKENZIE P.C. M.A., LL.B. Minister

GEOGRAPHICAL SECTION, GENERAL STAFF

CANADA, SHEET 31 $\frac{G}{6}$

S-A- 3/25

Surveyed and Reproduced by the Geographical Section, General Staff
DEPARTMENT OF NATIONAL DEFENCE.
Original Survey 1909
Reprinted 1939.
Magnetic Declination 13°35' W. at centre of sheet Aug. 1936.

REFERENCE

RUSSELL

ONTARIO

Scale. One Inch to One Mile = 1/63360

Contour Interval 25 Feet

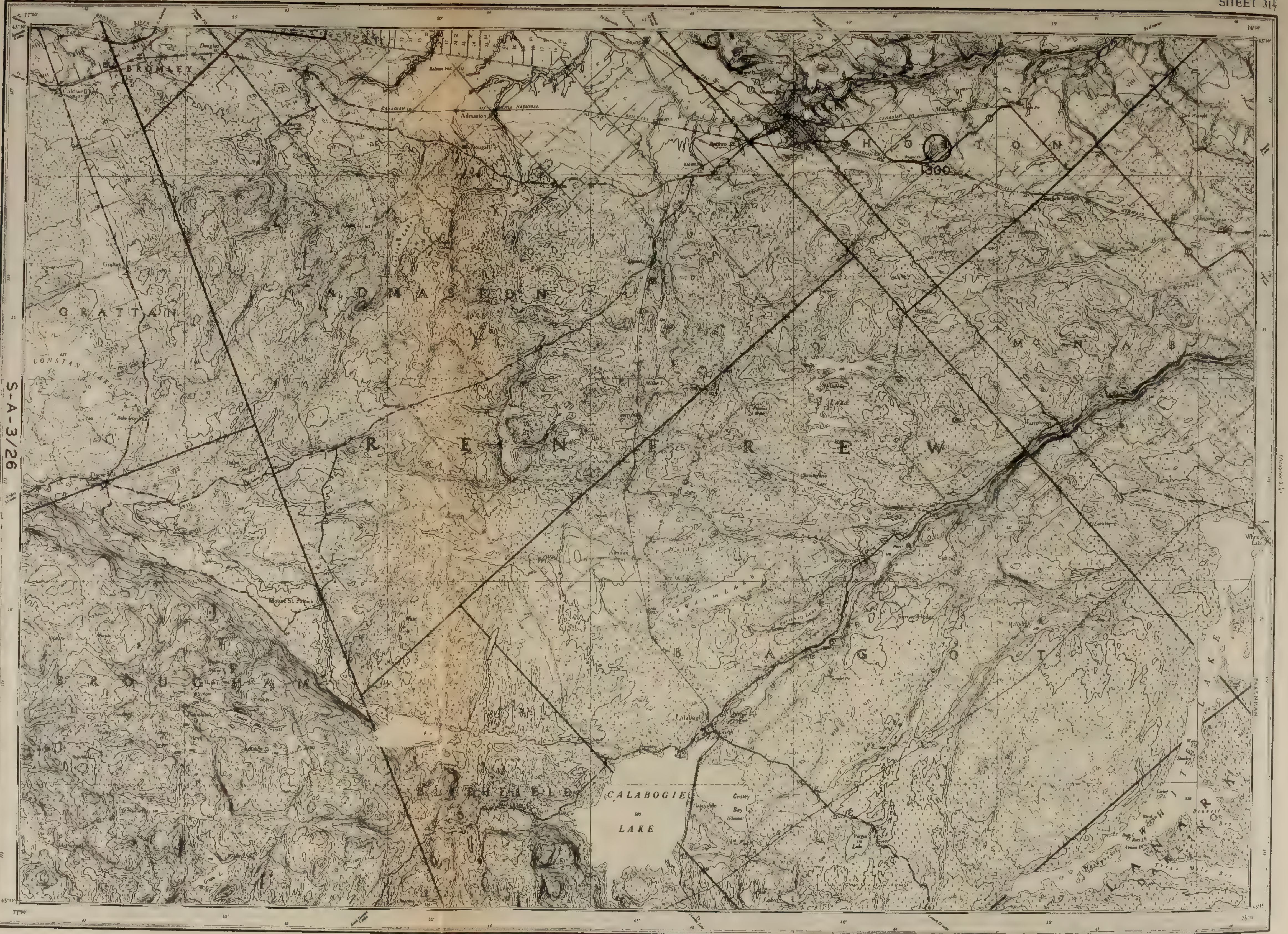
All Elevations in Feet above Mean Sea Level

REFERENCE

NATIONAL TOPOGRAPHIC SERIES

Canada
Department of Mines and Resources
SURVEYS AND ENGINEERING BRANCH
HYDROGRAPHIC AND MAP SERVICE

SHEET 31 F/7



Magnetic variation approximately 13° 30′ west of true north at Renfrew January, 1935

RENFREW

ONTARIO

Scale 1 mile to 1 inch or 1:63,360

1 ¾ ½ ¼ 0 1 2 3 4 5 Miles

1 000 0 1 000 2 000 3,000 4,000 5 000 6 000 7 000 8,000 9 000 Yards

Contour interval 25 feet

Datum is mean sea level.

NOTE: The grid squares provide a ready method of referring to or locating features. They are four miles to a side and subdivided into quarters by dotted lines. The east and west sides of the squares are not true north and south lines, but have a deflection to the west varying from 21′ on the east side of the map to 43′ on the west side. Any square is identified by the numbers along the outer border, for example Calabogie will be found in the southeast quarter of square 45-174.

Price 25 cents
Folder form 35 cents Linen backed 50 cents

S-A-3/26

Compiled, drawn and printed at the Hydrographic and Map Service, Labelle Building, Ottawa, 1940, where additional copies may be obtained.
Surveyed, 1936, by the Department of National Defence, photographs by the R.C.A.F.

REFERENCE

- Boundary county
- ,, township
- Railway steam, single track — Station, Cutting, Embankment
- Main highway (wide) — Paved, Gravelled
- Secondary highway (narrow) — Paved, Gravelled
- Other motor roads
- Wagon road
- Sleigh road, trail or path
- Highway route number
- Telephone or telegraph line, trunk route
- Electric power line
- Bridge stone, concrete, iron or wood
- Woods, deciduous
- ,, coniferous
- Marsh
- Falls and rapids
- Shoal, sand or gravel
- Gravel or sand pit

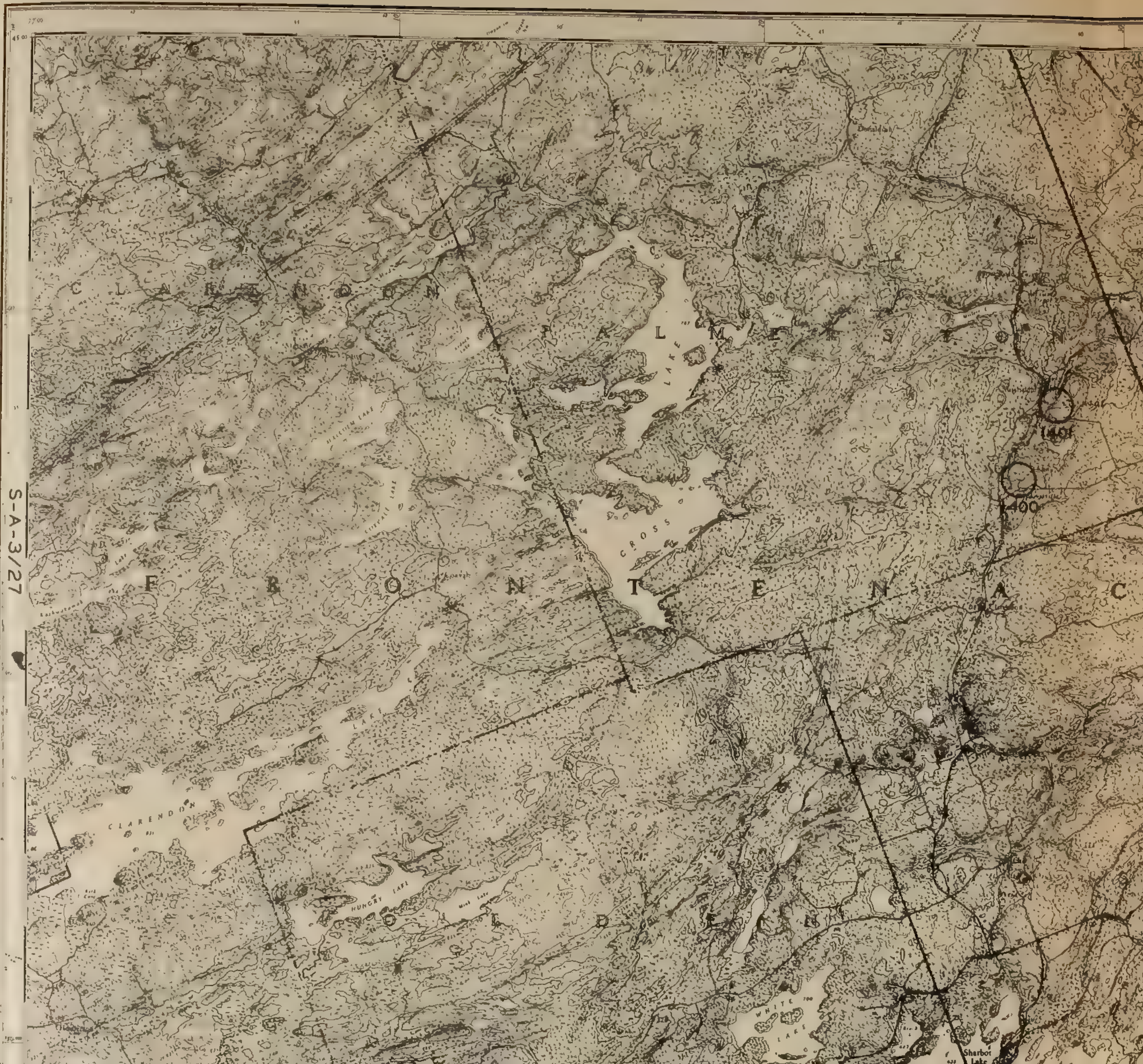
REFERENCE

Contours	175
Depression contour	500
House	
Barn	
Sawmill	S.M.
School	S
Post office	P
Telegraph office	T
Telephone exchange	T
Church with spire	
,, with tower	
,, without either	
Cemetery	C
Geodetic bench mark	B.M. 389.16
Geodetic triangulation station	△
Concession number	IX
Lot number	21
Height in feet	518

NOTE. On the above index the sheets published are shown tinted green

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE
GEOGRAPHICAL SECTION, GENERAL STAFF



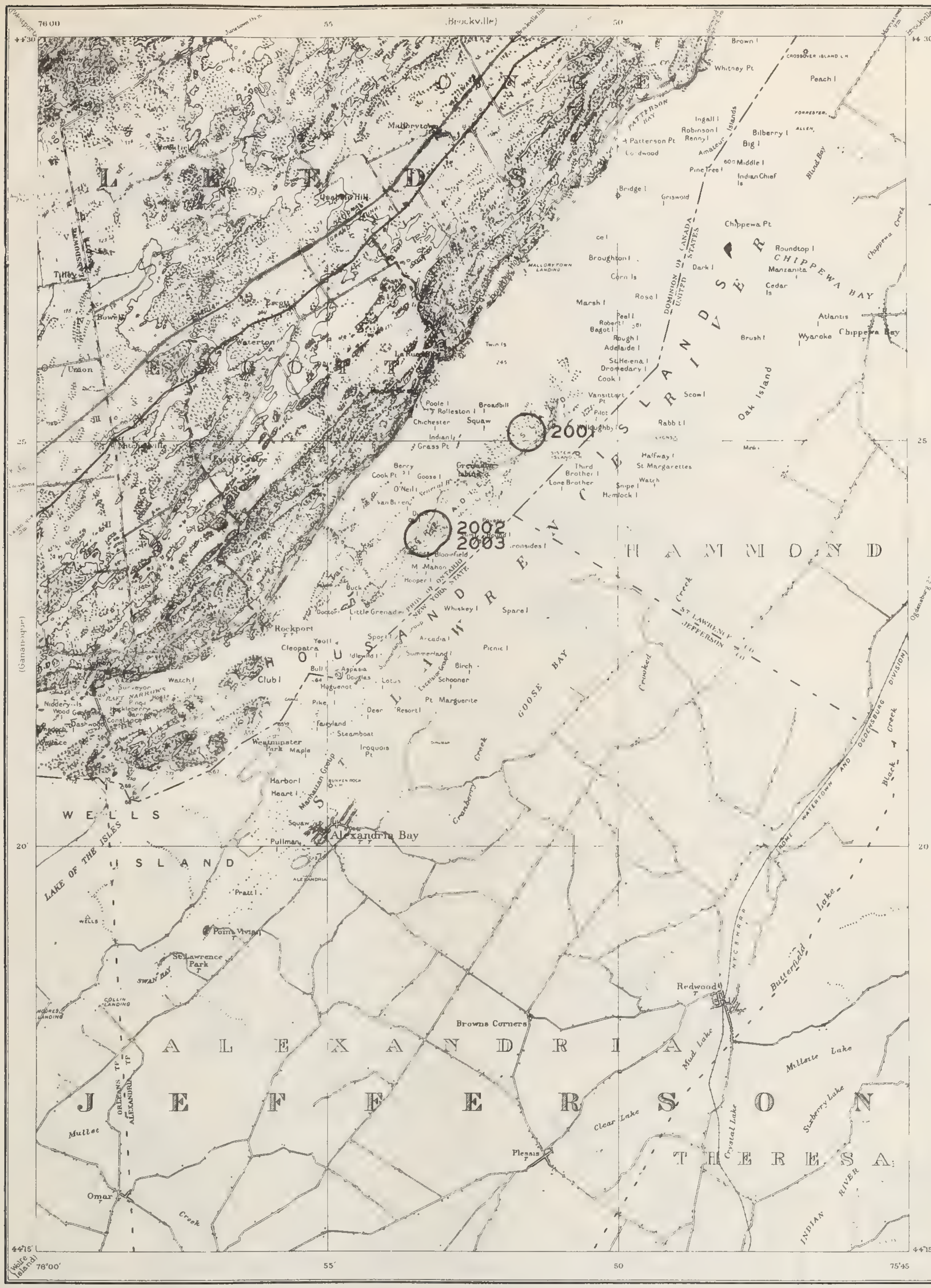
TOPOGRAPHIC MAP

CANADA I INCH TO I MILE

ONTARIO

MALLORYTOWN SHEET

SHEET Nº 31 B/5



Published by the Geographical Section General Staff
Department of National Defence 1926
Reprinted 1939

Portion of United States taken from U.S. Geological Survey

Magnetic Declination 12°09' W at Mallorytown, Aug 1923 (Local attraction)

Polyconic Projection

Elevations in feet above Mean Sea Level

Surveyed in 1925 by the Geographical Section, G.S. with aid of aerial photos by Royal Canadian Air Force

Scale ~~1:63360~~ or 1 Inch to 1 Mile

Miles 1 0 1 2 3 4 5 Miles

Yards 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 Yards

Contour interval 25 Feet

Provincial Boundary
County
Township
Railways { *Single Track* / *Double* / *Railway on road*
Cutting
Embankment
Road, Paved
" *Improved*
" *Other*
" *Wagon or Unused Road*
Path
Canal and Locks
Bridges { *Masonry* / *Steel or Iron* / *Wood*
Swing Bridge (Steel or Wood)
Dam (Wood or Masonry)
Wagon Ford
Ferry
Cliff
Quarry
Sand or Gravel Pit

Railway Station
Post Office
Church { *Without spire or tower* / *With* / *Centre of cross is centre of spire*
Mill { *Saw mill* / *Grist or Flour mill* / *Other mill or factory*
School
Blacksmith shop
Hotel or tavern
House
Telegraph or Telephone Line
Office
Telephone
Lighthouse
Cemetery
Triangulation Station
Altitudes
Bench Marks
Marsh
Woods (*Deciduous*) (*Coniferous*)
Contours (*Elevation*) (*Depression*)

ONTARIO 75°45'-44°15'

Highway Routes 2.etc

S-A-3/28

INDEX TO ADJOINING SHEETS

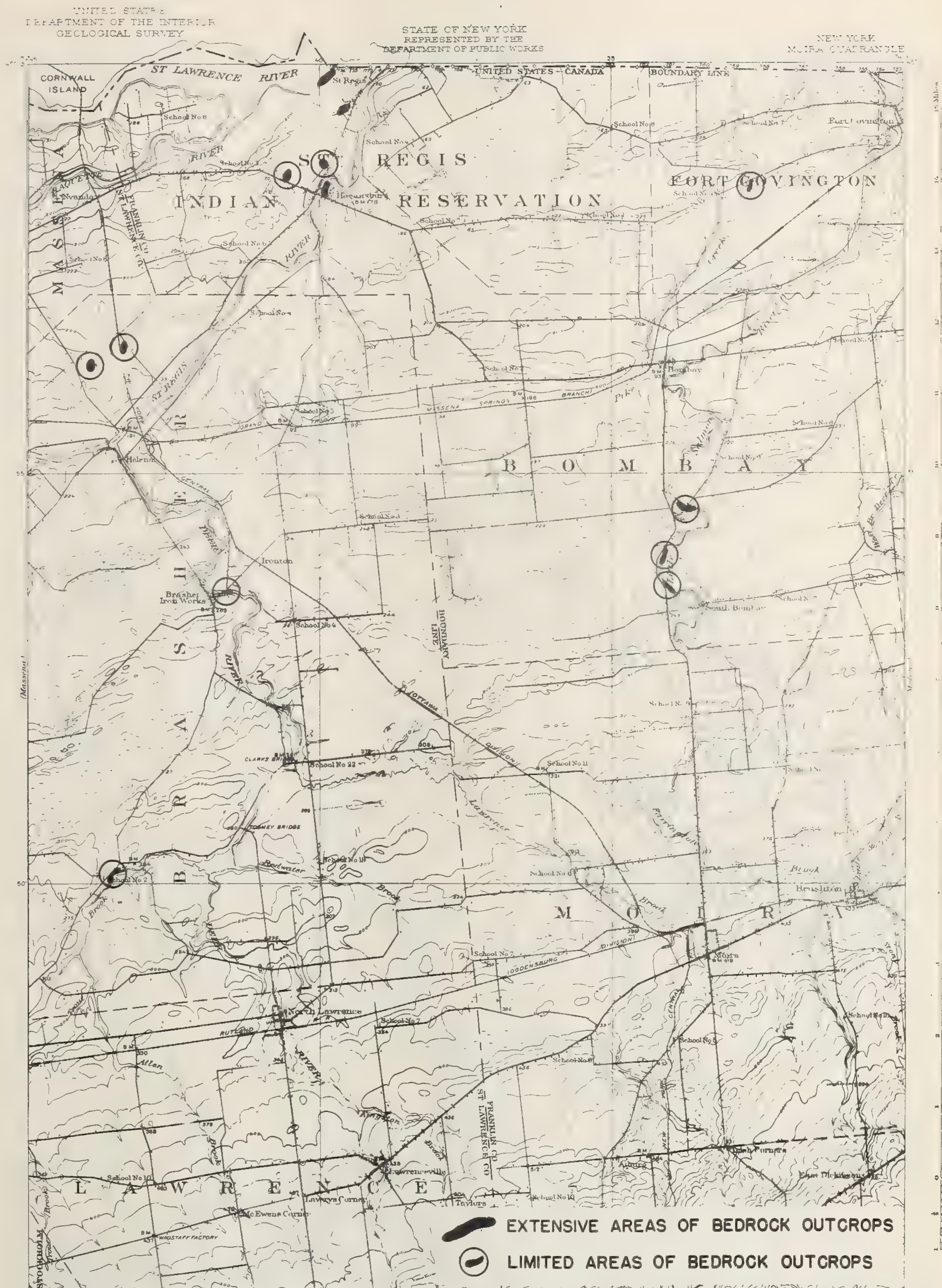
WESTPORT	BROCKVILLE
GANANOQUE	
WOLFE ISLAND	

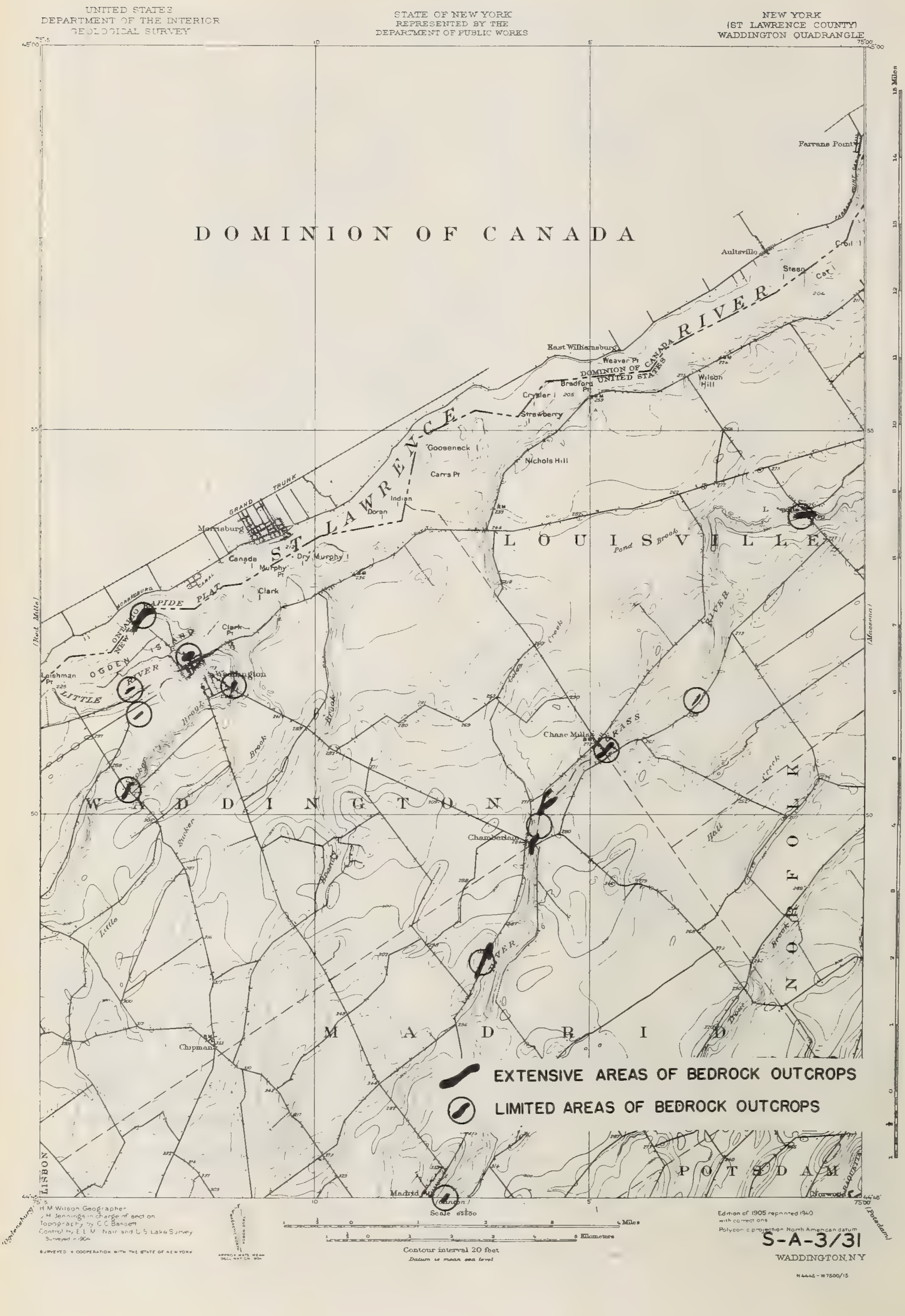
PRICE 25 CENTS

G-650/4

MASSENA QUADRANGLE
SHEEK ISLAND
BARNHART ISLAND
CROIL ISLAND
ST LAWRENCE
M A S S E N A
Massena Center
MASSENA
L O U I S V I L L E
Massena Springs
B R A S H E R
Brasher Center
N O R F O L K
Raymondville
Norfolk
S T O C K H O L M
Brasher Falls
Winthrop
EXTENSIVE AREAS OF BEDROCK OUTCROPS
LIMITED AREAS OF BEDROCK OUTCROPS
Contour interval 20 feet

S-A-3/29


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS
NEW YORK
MOIRA QUADRANGLE
UNITED STATES – CANADA BOUNDARY LINE
ST LAWRENCE RIVER
CORNWALL ISLAND
ST REGIS
INDIAN RESERVATION
FORT COVINGTON
MASSENA
BOMBAY
BRASHER
MOIRA
LAWRENCE
Helena
Ironton
Brasher Iron Works
North Lawrence
Moira
Lawrenceville
Taylors
McEwens Corner
EXTENSIVE AREAS OF BEDROCK OUTCROPS
LIMITED AREAS OF BEDROCK OUTCROPS
R B Marshall, Chief Geographer
Frank Sutton Geographer in charge
Topography by Glenn S Smith and C H Davey
Control by International Boundary Survey
International Waterways Commission
Surveyed in 1915
SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK
Contour interval 20 feet
S-A-3/30



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS
NEW YORK
(ST LAWRENCE COUNTY)
WADDINGTON QUADRANGLE
DOMINION OF CANADA
ST LAWRENCE RIVER
DOMINION OF CANADA
UNITED STATES
LOUISVILLE
WADDINGTON
MADRID
NORFOLK
POTSDAM
LISBON
Farrans Point
Aultsville
East Williamsburg
Morrisburg
Waddington
Chase Mills
Chamberlain
Chipman
Madrid
EXTENSIVE AREAS OF BEDROCK OUTCROPS
LIMITED AREAS OF BEDROCK OUTCROPS
Contour interval 20 feet
Datum is mean sea level
Edition of 1905 reprinted 1940
S-A-3/31
WADDINGTON, N.Y.

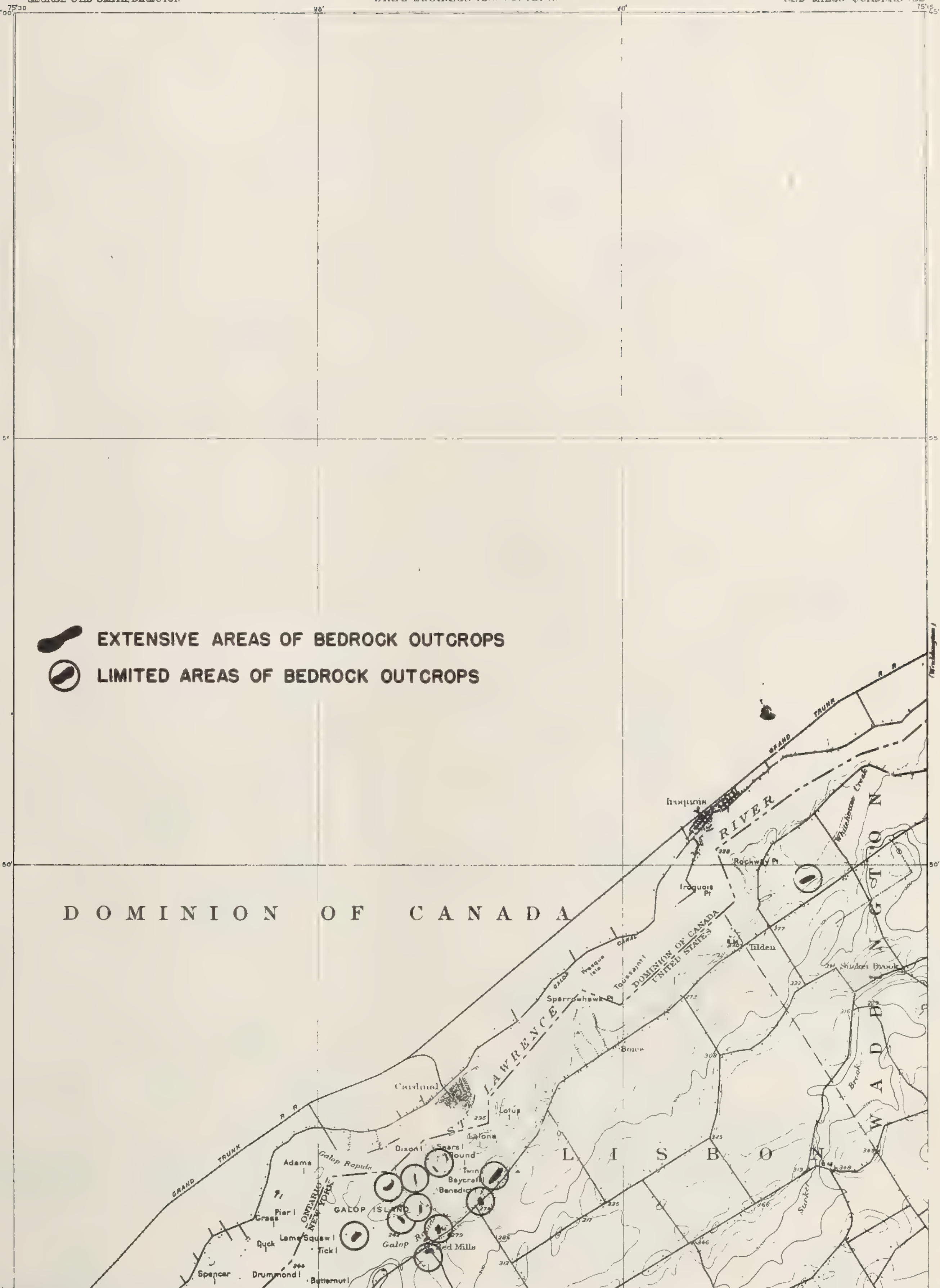
U.S.E.D.

DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, SECRETARY
U S GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

TOPOGRAPHY

STATE OF NEW YORK

NEW YORK
(ST. LAWRENCE COUNTY)
RED MILLS QUADRANGLE



H M Wilson Geographer
J H Jennings, in charge of section
Topography by C C Bassett
Control and shoreline by U S Lake Survey and E. L. Mc Nair
Surveyed in 1904

SURVEYED IN COOPERATION WITH THE STATE OF NEW YORK

APPROXIMATE MEAN DECLINATION 1906

Scale $\frac{1}{62500}$

Contour interval 20 feet
Datum is mean sea level

S-A-3/32

RED MILLS
Edition of 1906
reprinted 1921

GQ-640/4

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE
HONOURABLE IAN A MACKENZIE, P.C., M.A., LL.B., Minister
GEOGRAPHICAL SECTION, GENERAL STAFF
(Alexandria 31 G)

CANADA, SHEET 31 G/2

S-A-3/33

CORNWALL

ONTARIO - QUEBEC

Scale: One Inch to One Mile = 1/63,360

Contour Interval 25 Feet

All Elevations in Feet above Mean Sea Level.

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE

GEOGRAPHICAL SECTION, GENERAL STAFF

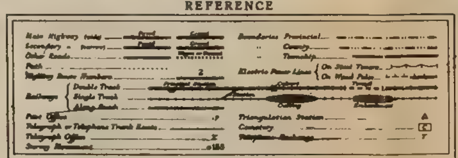
(Winchester 31 $\frac{B}{3}$)

CANADA, SHEET 31 $\frac{B}{14}$

S-A-3/34

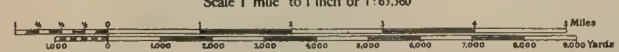
Surveyed and Reproduced by the Geographical Section, General Staff.
DEPARTMENT OF NATIONAL DEFENCE.
Original Survey 1906.
Resurveyed 1938, with aerial photographs taken by R.C.A.F.
Reprinted 1940.
Magnetic Declination 11° 07′ W. at centre of sheet, 1939.

REFERENCE



MORRISBURG
ONTARIO

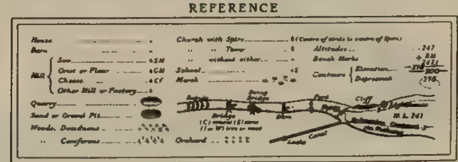
Scale 1 mile to 1 inch or 1:63,360

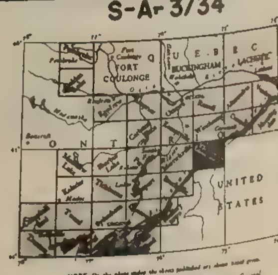


Contour interval 25 Feet
All Elevations in Feet above Mean Sea Level.

NOTE. Grid squares may be drawn on this map by joining the corresponding divisions shown along the outer border; this will provide a series of four mile squares which form a convenient system of reference. The numbers of the squares are also given along the outer border.

REFERENCE





Copies of these maps may be obtained from the Surveyor General, Department of Mines and Resources, Ottawa. Price 25 cents.

TOPOGRAPHIC MAP

CANADA 1 INCH TO 1 MILE

ONTARIO

WINCHESTER SHEET

SHEET Nº 31 $\frac{G}{2}$

Published by the Geographical Section, General Staff
Department of National Defence 1909
Reprinted 1933

Magnetic Declination 13°38' W at Winchester, Jan 1933
Polyconic Projection
Elevations in feet above Mean Sea Level
Surveyed in 1905 by the Geographical Section, G.S.

Scale 1 inch to 1 Mile

Contour interval 25 Feet

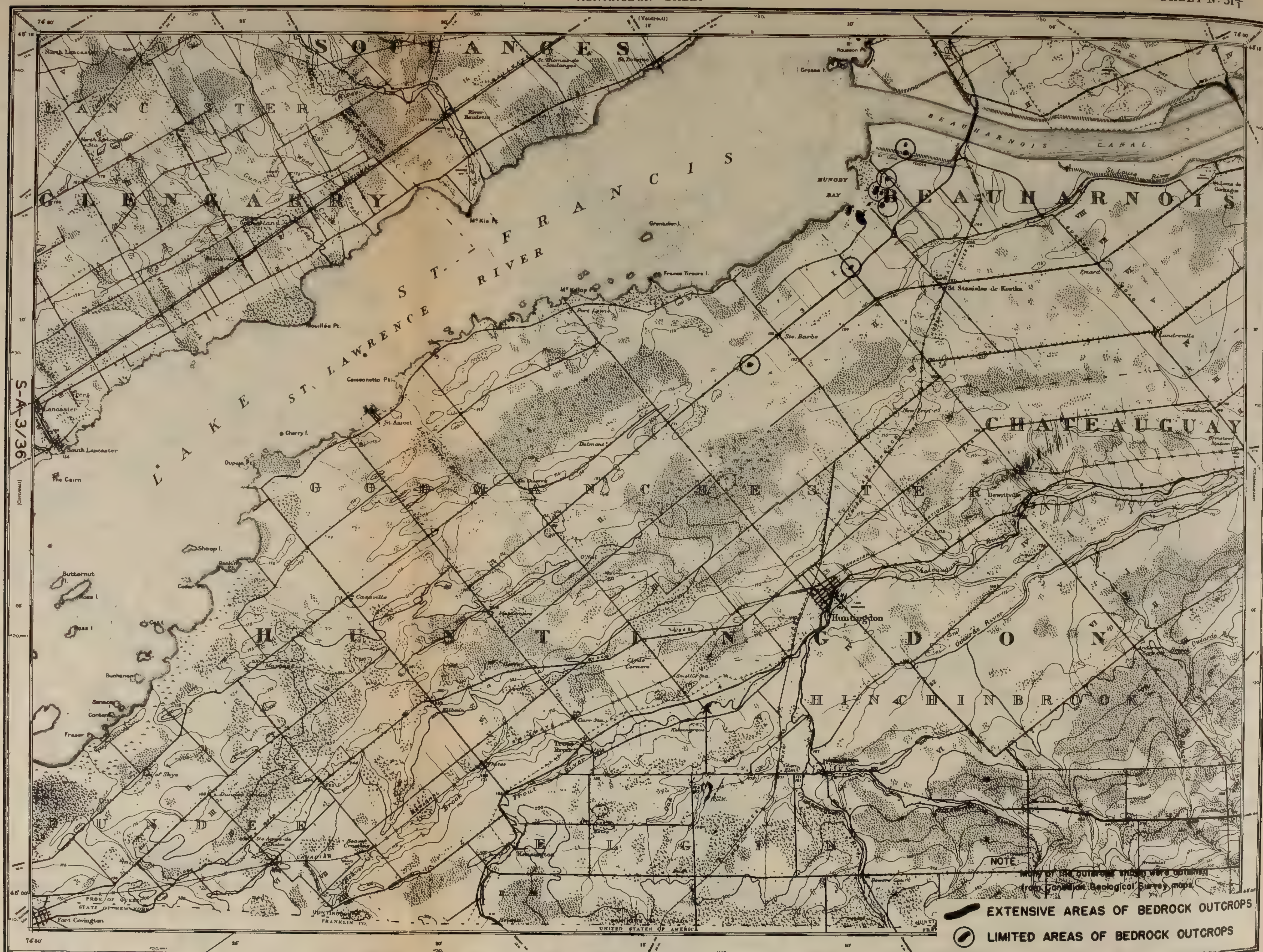
S-A-3/35 ONTARIO, 75 00 - 45 00

Highway Routes 31, etc.

CANADA 1 INCH TO 1 MILE

TOPOGRAPHIC MAP
QUEBEC – ONTARIO
HUNTINGDON SHEET

SHEET No 31 G/1



Published by the Geographical Section, General Staff,
Department of National Defence 1909.
Revised 1935.

International Boundary and adjacent topography from International Boundary Commission

Magnetic Declination 14°27′ W. Huntingdon Dec. 1934.
Polyconic Projection
Elevations in feet above Mean Sea Level.
Surveyed in 1907 by the Geographical Section, G.S.

Scale 1 Inch to 1 Mile

Contour interval 25 Feet

INDEX TO ADJOINING SHEETS

ALEXANDRIA	VALLEYFIELD	LACHINE
CORNWALL		CHATEAUGUAY

PRICE 25 CENTS

S-A-3/36

ONTARIO – QUEBEC 74°00′-45°00′

Highway Routes 2 etc

PART THREE

INVESTIGATIONS OF SAND AND GRAVEL SOURCES
FOR ROADS, FILTER AND BACKING MATERIALS

TABLE OF CONTENTS

TABLES

PLATES

U. S. SAND AND GRAVEL PIT PHOTOGRAPHS

CANADIAN SAND AND GRAVEL PIT PHOTOGRAPHS

MAPS

REPORT OF INVESTIGATIONS OF
SAND AND GRAVEL SOURCES
FOR
ROADS, FILTERS AND BACKING MATERIALS

November 1941

I. INTRODUCTION

1. Purpose and Scope.

The purpose of this report is to describe and to present the results of the investigations of sand and gravel sources for roads, filters and riprap backing for the St. Lawrence River Project as conducted by the U. S. Engineer Office, Massena, New York, between October 1940 and December 1941. The investigations included the location and estimate of the extent of all natural deposits of sand and gravel in the vicinity of the St. Lawrence River Project and the determination of the general characteristics of the materials within the deposits. This data provides information for the economical design, cost estimates, and specifications for gravel road surfaces, filters, and riprap backing. The investigations have been confined to areas within approximately 10 miles south and 20 miles north of the St. Lawrence River which contain deposits considered to be within economical truck haul of some structure of the Project. The field investigations were made partly in conjunction with the investigations to locate suitable gravel deposits for concrete aggregates. This report, however, does not discuss the suitability of the deposits for concrete aggregates which is presented in a separate report on file in the district office.

II. REGIONAL GEOLOGY

2. General.

The area in which the investigations were conducted is a region of low relief which has been greatly modified by glaciation and marine invasion. The region as a whole is underlain by relatively flat-lying Paloozoic sedimentary rocks. These rocks have been classified as lower Ordovician in age. After the retreat of the last glacier the bedrock was blanketed by a very irregular deposit of glacial till composed of clayey to silty, gravelly sand with boulders. The ice left numerous low, elongated till ridges plastered on the bedrock. These ridges usually paralleled each other and in general are parallel to the direction of the ice movement. Because of conditions at the ice front during withdrawal of the glacier, aqueo-glacial deposits are rare or entirely absent. Only one deposit of this nature, located at Baudette River, Quebec, was found in the entire region. Because of the tremendous weight of the ice, the land was down warped below sea level. Consequently as the ice wasted back, the sea flooded the St. Lawrence Valley to form the Champlain Sea. Great deposits of clay were laid down in the valleys and sometimes blanketed the lower till ridges. The higher till ridges appeared as islands in this inland sea. Continued wave and current action on these exposed till ridges resulted in the development of beaches and bars on the slopes. As the land slowly rebounded after the relief of the load of the ice mass, the sea retreated leaving a greatly modified region of wide clay and sand filled flat valleys above which rise the beached till hills.

3. Extent of Exploration.

All possible sources of sand and gravel were investigated from the town of Red Mills, New York on the west to Fort Covington, New York on the east. The investigation was conducted within approximately 20 miles north of the St. Lawrence River and 10 miles south of the St. Lawrence River, except in the Massena Quadrangle which was completely investigated and mapped. All exploration conducted to date has been essentially superficial in character, and the quantity estimates in the deposits have been made chiefly by a visual examination. More detailed exploration in the form of test pits should be employed for more accurate estimates of the available materials.

4. Method of Exploration.

Field exploration consisted of geological reconnaissance in the region by road trips and cross country walks. Samples were taken from a few of the deposits which contain the most satisfactory materials. The United States Geological Survey and Canadian Department of Defense topographic maps were used to map the surficial deposits of the region so that favorable localities could be more intensively investigated and barren areas could be eliminated. All available geological reports and maps were also studied. Investigations in the vicinity of the St. Lawrence River in Canada were facilitated by study of a report and maps published in 1922 by the Canadian Department of Mines, "Report on Structural Materials along the St. Lawrence River, between Prescott, Ontario and Lachine, Quebec". All existing exposures such as road cuts and existing pits were visited. From the faces of a few of the more promising deposits 50 to 100 lb. samples were taken for testing. To insure natural material, the samples were taken from the bottom of shallow trenches excavated in the faces. A complete inspection report including pertinent data, estimates by visual examination of available quantities, and percentage of gravel, sand and silt, is included in this report. Photographs were taken of a few representative pits and are shown on Plates I to XII, inclusive.

5. Location and Notation of Deposits.

Plates XIII to XXII inclusive are United States and Canadian topographic maps showing the location and number of each deposit examined. For convenience in locating deposits, a rectangular area coordinate system was established. The 9 rectangles of each United States topographic map were subdivied visually into 9 smaller rectangles. (See Plate XIII for illustration.) The location of each deposit has been referred to by two numbers, the first denoting a large rectangle and the second number a small visionary rectangle. The rectangles are numbered as shown on Plate XIII. The location of each deposit on the Canadian maps of Cornwall, Merrickville, Morrisburg, and Kemptville have been referred to the grid-system shown on the maps (Plates XXI, XVII, XIX, and XVIII). The location of each deposit on the Canadian maps of Winchester and Huntingdon have been referred to by two numbers similar to the United States maps (See Plate XX). In order to easily determine the map on which a deposit was located, one hundred numbers were assigned to each map. The deposits on each map have been numbered consecutively. Tables I and II show the locations and numbers of all deposits examined.

IV. LABORATORY TESTS

6. General.

Laboratory tests were made to determine the gradation of the samples taken from deposits as described in paragraph No. 4. The usual screen analysis was made by first sieving the material on a 1/4-inch screen. The coarse faction was then sieved with 2-inch, 1-inch, ½-inch, and 1/4-inch screens and the finer faction with #10, #14, #28, #48, #100, and #200 sieves. All stones over 6 inches in diameter were removed from the sample in the field. The results of the tests are shown in Table III. The estimated percentage of material over 6 inches in diameter made in the field is also shown on Table III. The results obtained from tests for concrete aggregate investigation which include some soundness tests and are pertinent to the deposits are tabulated in Table IV. The results published in the Canadian Department of Mines Report pertinent to the deposits are shown on Table III.

V. CHARACTERISTICS OF DEPOSITS AND MATERIAL

7. General.

The sand and gravel sources of the region are chiefly marine beaches and bars on the till hills as determined by geological study and these investigations. Only one aqueo-glacial deposit was located in the entire area. This deposit, which is near the Baudette River, is extensive and shows the gradation and stratification which is typical of aqueo-glacial deposits. The character of the sand and gravel in this deposit is essentially the same as material found in the regional marine beaches and bars with the exception of a slightly larger amount of granitic material which is foreign to the region. The extent and character of the materials are different in the various regional bars and beaches. The deposits vary in extent from insignificant superficial deposits to large well developed features. Most of the deposits are slightly stratified. The various deposits contain uniform sands, well graded silty gravels, and clean sandy gravels. Most of the deposits which contain an appreciable quantity of gravel also contain numerous cobbles and boulders. This variation in extent and gradation of materials is the result of the various factors effecting the action of the waves which formed the deposits. Plates I to XII inclusive are photographs of typical deposits.

8.

In most of the deposits visited considerable rotten stone and platey particles were found. This condition is characteristic of most of the sand and gravel deposits in the region, and is the result of the weathered condition of the pre-glacial rock surface, the natural structure and chemical nature of the sedimentary rocks from which the gravels originated, and the severe climatic conditions to which these gravels have been subjected. The presence of a poorly-bonded, uniform grained sandstone and the quantity of shale in the deposits also contribute to the apparent unsound nature of the sands and gravels. Most of the deposits also contain a variable amount of marine shells. Although the sands and gravels in the deposits in general are

structurally unsound for concrete aggregates, (See Table IV) it is believed that they are sufficiently sound for roads, filters and backing. However, if the material is rolled, many of the particles will break down to finer particles, and the percentage of fines after construction may be greater than found in the natural deposit.

9.

The extent of the deposits and the gradation of the materials are shown in Tables III and V and on the attached inspection reports. The results of the investigations show that most of the deposits contain many cobbles and boulders and more than 30% gravel (greater than 1/4-inch), and between 3 and 15 percent silt of the materials passing the 1/4-inch screen. It is estimated from these investigations that within the area explored, there are available 800,000 and 1,000,000 cu. yds. of well graded sand or sand and gravel in the United States and Canada respectively.

VI. RECOMMENDATIONS AND CONCLUSIONS

10. Suitability of Available Material.

Materials available from the sand and gravel deposits in the local region of the Project are satisfactory for use as road surfaces, filters and sand and gravel backing. Although the materials in general are not sufficiently sound for concrete aggregate, they are satisfactory for all other sand and gravel requirements. By a study of the data presented in this report economical designs and specifications for available materials in the vicinity can be made. The difference in gradation of the materials in the various deposits, affords an opportunity to select the deposits which contain the most suitable material for the proposed purpose. The deposits containing materials with the least quantity of silt may be utilized as filter material, and that containing the highest percentage of gravel can be utilized for sand and gravel backing. Deposits containing well graded material with a large percentage of silt may be utilized for road surfaces. The materials in most of the deposits located can be utilized for one of the three required uses.

11. Future Investigations.

Before final selection of any sand and gravel deposit in the region is made, further and more detailed investigation to determine the depth, extent, and characteristics of the materials in the deposit should be conducted so that more accurate estimate of the quantity of suitable material available can be made. It appears that field exploration in most of the deposits should consist of test pits 6 to 20 feet deep instead of drill holes, since the deposits are superficial, overlying a very irregular glacial till surface, and samples obtained by usual drilling method are insufficient in size to determine the variation and gradation of materials. The gradation of large representative samples taken from the test pits should be obtained in the field and laboratory to determine if the deposits contain suitable materials.

12. Apparent Most Satisfactory Deposits.

The deposits which appear from these investigations to be the most

accessible to the proposed structures and most extensive, and contain material with an appreciable percentage of gravel and only a small amount of silt are tabulated in Table V. These deposits appear to be the most suitable sources for filter and backing material if it is desired to obtain both materials from one borrow pit. Other deposits not tabulated but located on Plates XIII and XXII inclusive are either limited in extent or contain materials which are suitable for either backing filters. Most of the deposits appear to contain materials suitable for road surfaces.

13. Quantities of Sand or Sand and Gravel.

It is estimated from these investigations that there are available in the United States within 10 miles of the St. Lawrence River in the vicinity of the St. Lawrence Project, 800,000 cu. yds. of natural sand and gravel deposits, and in Canada within 20 miles of the river 1,000,000 cu. yds.

TABLE I
LOCATION OF SAND AND GRAVEL DEPOSITS
ON U.S. TOPOGRAPHIC QUADRANGLES
BY
RECTANGULAR COORDINATE SYSTEM

Pit No.	Quadrangle	Rectangle	Pit No.	Quadrangle	Rectangle
	MASSENA			MOIRA	
1	"	4-7	100	"	4-1
2	"	7-7	101	"	4-4
3	"	7-7	102	"	4-6
4	"	5-5	103	"	9-1
5	"	5-5	104	"	6-1
6	"	8-9	105	"	2-8,9
7	"	9-7	106	"	4-3
8	"	7-4	107	"	3-5
9	"	5-6	108	"	1-9
10	"	3-2			
11	"	5-5		WADDINGTON	
12	"	1-9	700	"	3-4
13	"	3-2	701	"	4-8
14	"	6-8	702	"	8-9
15	"	8-2	703	"	9-2
16	"	7-6	704	"	7-5
17	"	7-3	705	"	6-1
18	"	5-7	706	"	8-3
19	"	5-4			
20	"	5-2		RED MILLS	
21	"	4-6	800	"	9-9
22	"	4-1	801	"	9-3
23	"	6-4	802	"	9-3
24	"	8-6			
25	"	8-6			
26	"	2-9			
27	"	9-2			
28	"	4-1			
29	"	4-1			
30	"	2-3			
31		2-3			

TABLE II
LOCATION OF DEPOSITS
ON CANADIAN TOPOGRAPHIC QUADRANGLES
BY
RECTANUGLAR GRID SYSTEM

Pit No.	Quadrangle	Rectangle
	CORNWALL	
1	"	172-72
2	"	172-71
3	"	173-70
4	"	172-70
5	"	169-69
6	"	169-68
7	"	169-68
8	"	170-67
9	"	170-67
10	"	170-67
11	"	171-68
12	"	170-67
13	"	169-66
14	"	169-66
15	"	171-66
16	"	173-67
17	"	172-70
	MORRISBURG	
100	"	168-63
101	"	168-63
102	"	168-63
103	"	168-63
104	"	165-62
105	"	165-61
106	"	165-60
	WINCHESTER	
200	"	6-6
201	"	6-7
202	"	12-4
203	"	17-6
204	"	18-5
205	"	18-5
206	"	17-4
207	"	16-6
208	"	16-5
209	"	9-8

Pit No.	Quadrangle	Rectangle
	MERRICK VILLE	
300	"	166-59
301	"	165-60
302	"	167-59
303	"	165-59
304	"	166-59
305	"	164-57
306	"	165-57
307	"	166-56
308	"	167-58
	KEMPTVILLE	
400	"	169-59
401	"	169-59
402	"	170-59
403	"	171-59
404	"	172-58
405	"	173-55
406	"	172-55
407	"	172-55
408	"	171-55
409	"	169-59
410	"	170-60
411	"	170-59
412	"	169-59
	HUNTINGDON	
800	"	3-4
801	"	3-4

ST. LAWRENCE RIVER PROJECT

TABLE III
INVESTIGATIONS OF SAND AND GRAVEL SOURCES FOR
ROAD FILL, FILTER AND BACKING MATERIALS
GRADATION OF MOST SATISFACTORY MATERIALS

Pit No.	Quadrangle	Sample Number	Est. % Greater Than 6"	% Between 6" and 1/4"	Results of tests on sample with material over 6" removed: Material from 6" to 1/4" — % Between 6" and 2"	% Between 2" and 1"	% Between 1" and ½"	% Between ½" and 1/4"	% of Total Passing 1/4"	Material less than 1/4" — % Passing sieves: #10	#14	#28	#48	#100	#200
1	Massena	1	15	67.8	24.5	22.8	13.3	7.2	32.2	60.5	55.3	47.5	23.0	11.1	7.2
9	"	1	5	49.8	12.6	19.4	-	11.6	50.2	79.0	70.8	43.8	16.5	7.0	4.2
11	"	1	1	58.6	17.4	16.6	-	24.6	41.4	73.0	61.7	38.1	21.6	6.9	3.2
12	"	1	8	62.2	23.8	21.1	10.4	6.9	37.8	75.2	63.2	37.8	9.8	1.6	0.6
16	"	1	10	57.0	18.6	14.6	-	23.5	43.0	65.4	59.2	31.4	6.2	2.4	1.6
17	"	1	3	56.6	18.0	13.9	13.1	11.6	43.4	64.9	57.5	38.7	18.7	10.3	5.1
18	"	1	3	60.9	10.1	24.3	15.9	10.6	39.1	77.6	68.7	54.8	25.2	8.1	5.5
20	"	1	8		-	-	-	-	-	81.4	75.8	54.5	16.5	9.0	6.8
22	"	1	.5	64.9	20.5	20.9	14.0	9.5	35.1	47.5	40.9	30.2	18.3	10.2	6.4
23	"	1	3	56.4	15.1	18.0	13.2	10.1	43.6	70.8	63.5	48.8	21.5	8.3	5.7
29	"	1	10	56.4	15.4	21.1	12.7	7.2	43.6	47.0	34.8	18.0	3.9	1.2	0.9
801	Red Mills	1	0	54.2	8.6	17.1		28.5	45.8	82.0	75.1	61.5	29.6	12.4	8.0
802	"	1	3	62.8	2.40	17.3	12.4	9.1	37.2	59.7	50.0	34.9	16.5	6.8	4.4
	CANADIAN QUADRANGLES				RESULTS OF TESTS ON CANADIAN MATERIALS										
800	Huntingdon	1	8							99.5	99.2	98.5	47.8	6.7	1.6
8	Cornwall	1	5							68.4	65.2	57.9	33.8	5.5	2.0
202	Winchester	1	3	21.6		2.4	7.7	11.4	78.4	60.2	45.6	22.1	5.6	1.1	0.6

FILE NO. S-A-2/59

TABLE IV

RESULTS FOR CONCRETE AGGREGATE INVESTIGATION

Results of Deposits in United States

Pit No.	% Passing Screen #4	#8	#16	#30	#50	#100	Sp. Gr.	Unit Weight Dry Rodded	% Voids	Compressive Strength Ratio 7 days	MgSO4 Soundness % loss (10 cycles) Ind. Screen loss weighted #8	#16	#30	#50	Aver.	% Loss Decantation
9	97.5	85.7	60.2	30.9	9.4	2.9	2.69	107.0	36.3	80.0	20.9	17.4	15.9	12.5	15.9	1.0
11	100.0	82.1	60.3	39.8	22.2	7.7	2.67	114.0	31.7	93.5	27.8	26.0	20.8	27.2	25.7	4.4
7	99.9	78.6	53.9	22.5	7.0	4.3	-	-	-	-	50.5	34.5	-	0	38.0	-
10	100.0	83.7	66.6	48.4	18.1	6.6	2.64	110.5	34.1	83.7	59.6	64.9	42.5	40.9	48.5	6.2
Results of Deposits in Canada																
900	100.0	92.4	74.0	33.8	14.5	4.4	2.65	-	-	94.3						2.4
902	100.0	87.7	63.3	45.5	24.8	5.6	2.65	-	-	92.3						1.8
300	99.8	77.4	54.8	36.5	13.3	3.7	2.74	112.0	34.6	96.2	18.9	27.0	28.2	23.7	24.0	1.6

TABLE V

APPARENT MOST SATISFACTORY DEPOSITS

	UNITED STATES					CANADIAN				
	Pit No.	Est. Total Cu. Yds.	Est. % Gravel	Est. % Sand	Est. % Silt in Sand	Pit No.	Est. Total Cu. Yds.	Est. % Gravel	Est. % Sand	Est. % Silt in Sand
Mile 75 to 90	800	80,000	55.0	45.0	5	300	250,000	65.0	35.0	5
	801	60,000	54.0	46.0	5	202	200,000	22.0	78.0	1.0
	802	50,000	63.0	37.0	5	207	8,000	50.0	50.0	7.0
Mile 90 to 95	28	8,000	65.0	35.0	8	208	9,000	60.0	40.0	7.0
	29	25,000	56.0	44.0	1	206	5,000	50.0	50.0	5.0
	703	10,000	30.0	70.0	6	209	10,000	55.0	45.0	5.0
Mile 95 to 110	9	250,000	50.0	50.0	4	200	500,000	54.0	46.0	4.0
	11 & 18	150,000	60.0	40.0	4	12	150,000	50.0	50.0	4.0
	20	50,000	55.0	45.0	5	8	10,000	50.0	50.0	5.0
	16	80,000	57.0	43.0	2	9	10,000	56.0	44.0	8.0
	31	10,000	55.0	45.0	5	15	10,000	55.0	45.0	10.0
	10	10,000	50.0	50.0	5					
	30	5,000	60.0	40.0	6					
East of Mile 110	105	10,000	70.0	30.0	8	800		60.0	40.0	3.0
						801		60.0	40.0	3.0

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of new section of Pit. No. 9, owned by Premo, $3\frac{1}{2}$ miles Southeast of Massena, N. Y.

December 1, 1941

File No. SL-93
Plate 1

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Pit No. 11, Massena, N. Y., owned by Walter Hartford. Stripping from Pit No. 18 can be seen at the tree line on extreme left edge of photograph.

December 1, 1941

File No. SL-94
Plate II

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up view of face, Pit No. 11, Hartford Pit, Massena, N. Y.

December 1, 1941

File No. SL-95
Plate II-A

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Pit No. 105, owned by town of Bombay, Located 3½ miles Southeast of Hogansburg, N. Y. Typical example of a boulder bar.

December 1, 1941

File No. SL-98
Plate IV

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up view of Pit No. 105 showing typical boulder bar material

December 1, 1941

File No. SL-99
Plate IV-A

File No. SL-102
Plate V-B

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up of gravel phase of Pit 800. The coarse gravel on surface is discardings from former pit operations.

December 1, 1941

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Pit No. 801, owned by F. C. Dunn, located 2½ miles Southeast of Rockway Point, N. Y. Extension of deposit can be seen along the entire sky line.

December 1, 1941

File No. SL-103
Plate VI

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Pit No. 802, owned by Frank Hunter. Pit located 2 miles Southeast of Rockway Point. Extension of deposit can be seen in ridge in background and extending to trees on left edge at photograph.

December 1, 1941

File No. SL-105
Plate VII

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up view of Pit No. 802. Pit being worked by town of Red Mills.

December 1, 1941

File No. SL-104
Plate VII-A

File No. SL-107
Plate VIII

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up of Canadian Pit No. 8. White spots on left half of photo are marine shells.

December 3, 1941

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Canadian Pit No. 8 owned by G. T. Coleman. Located 3 miles Northeast of Moulinette, Ontario.

December 3, 1941

File No. SL-106
Plate VIII-A

U. S. Engineer Office
St. Lawrence River District
Messena, N. Y.

Close up of Canadian Pit No. 8. Notice abundance of marine shells.

December 3, 1941

File No. SL-108
Plate VIII-B

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

General view of Canadian Pit No. 12. Northfield Station Railroad pit 6½ miles Northwest at Moulinette, Ontario.

December 3, 1941

File No. SL-110
Plate IX

File No. SL-112
Plate X-A

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Close up of Canadian Pit No. 200. Considerable calcite cemented material, note white calcite on boulders in foreground.

December 3, 1941

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Typical Marine Beach, Canada. Pit No. 200 is located in west end of this deposit.

December 3, 1941

File No. SL-113
Plate XI

File No. SL-115
Plate XII

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Canadian Pit No. 202, Sandtown Pit owned by Sylvia Lachapelle, 11 miles north of Aultsville, Ontario. General view of coarse gravel phase of pit.

December 3, 1941

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Canadian Pit No. 202, Sandtown Pit, close up of view of gravel phase of pit.

December 3, 1941

File No. SL-116
Plate XII-A

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Canadian Pit No. 202. Sandtown Pit owned by Sylvia Lachapelle, 11 miles north of Aultsville, Ontario. General view of sand phase of pit.

December 3, 1941

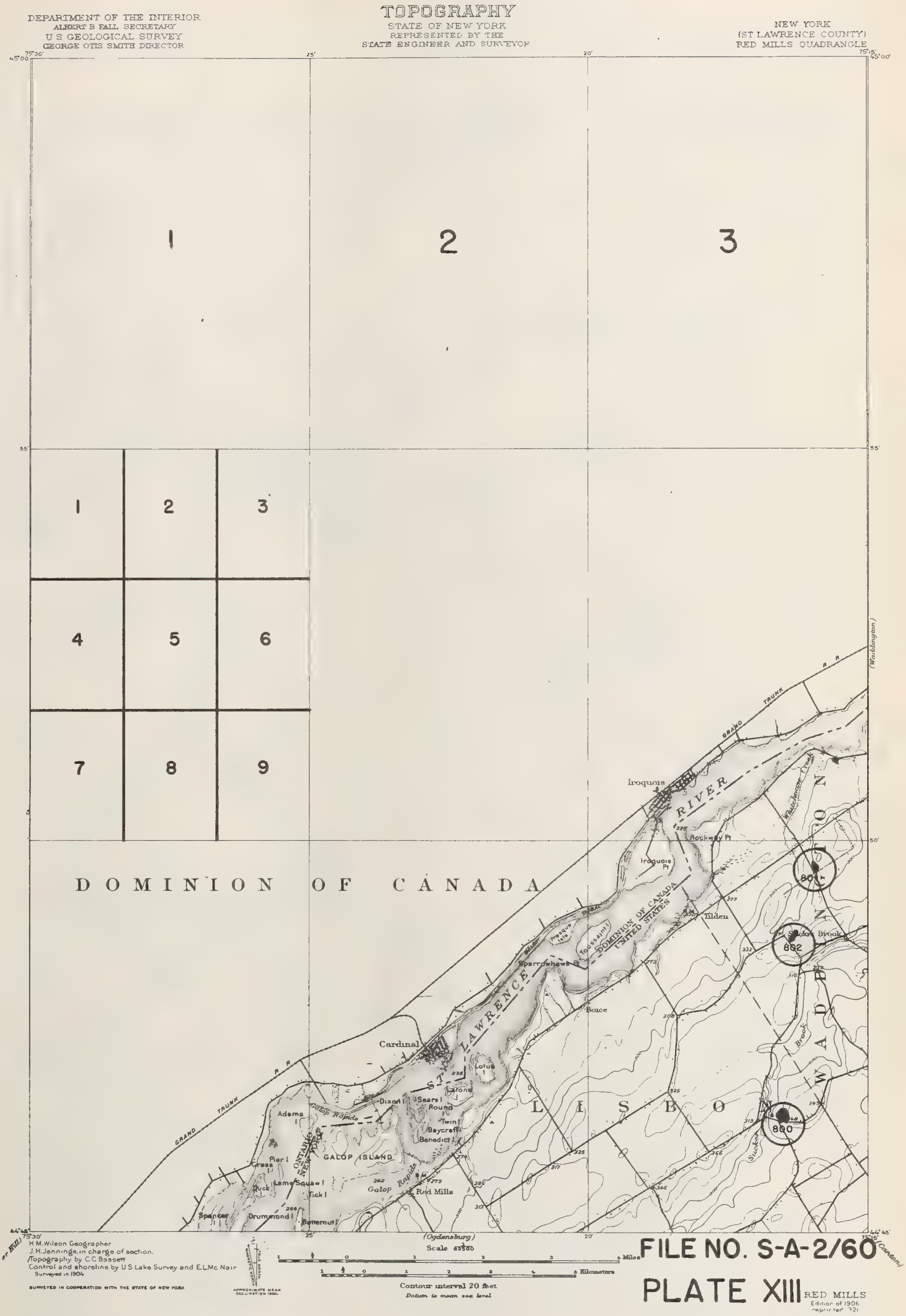
File No. SL-117
Plate XII-B

U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Canadian Pit No. 202, Sandtown Pit, close up of sandy phase of pit.

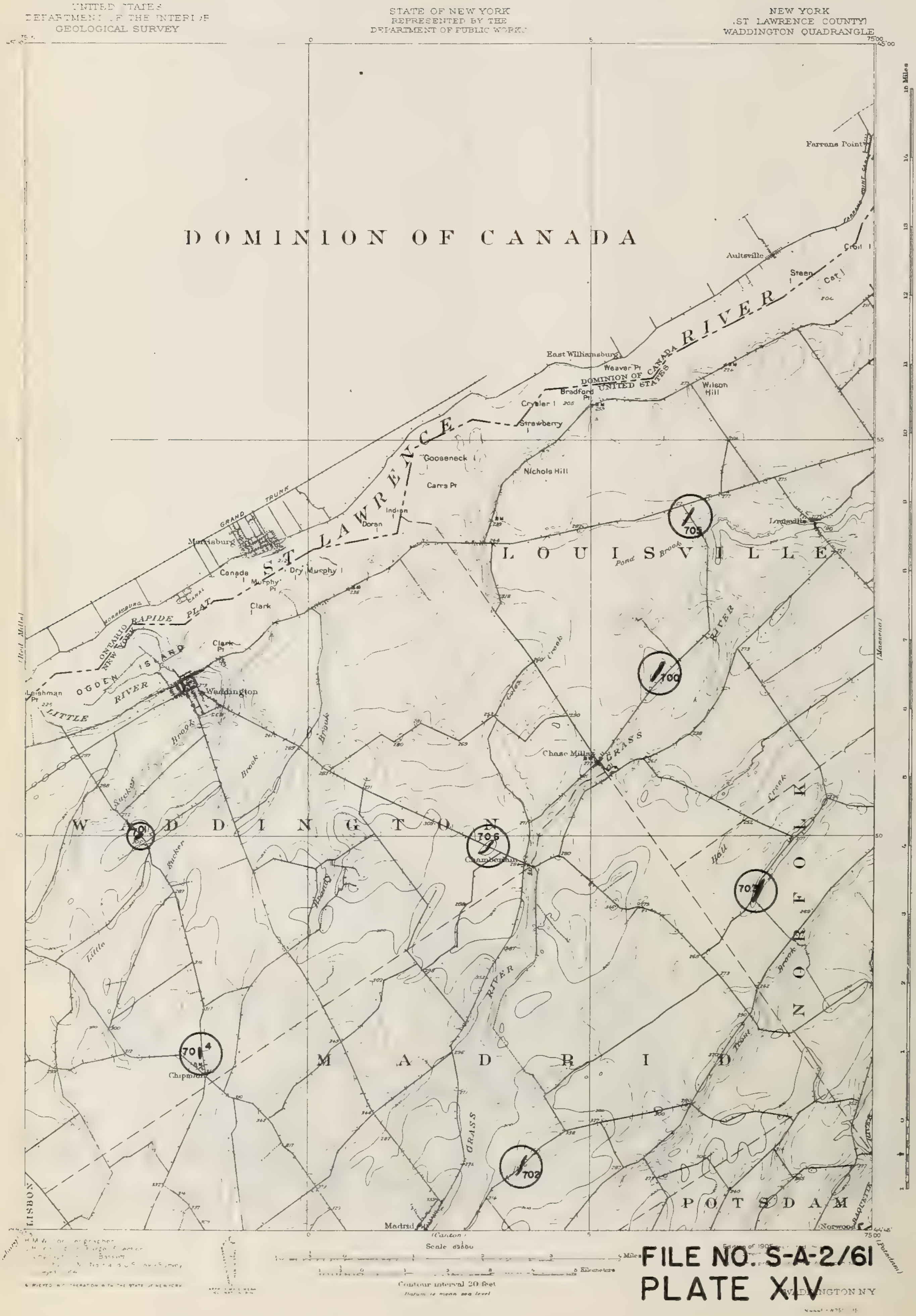
December 3, 1941

File No. SL-114
Plate XII-C



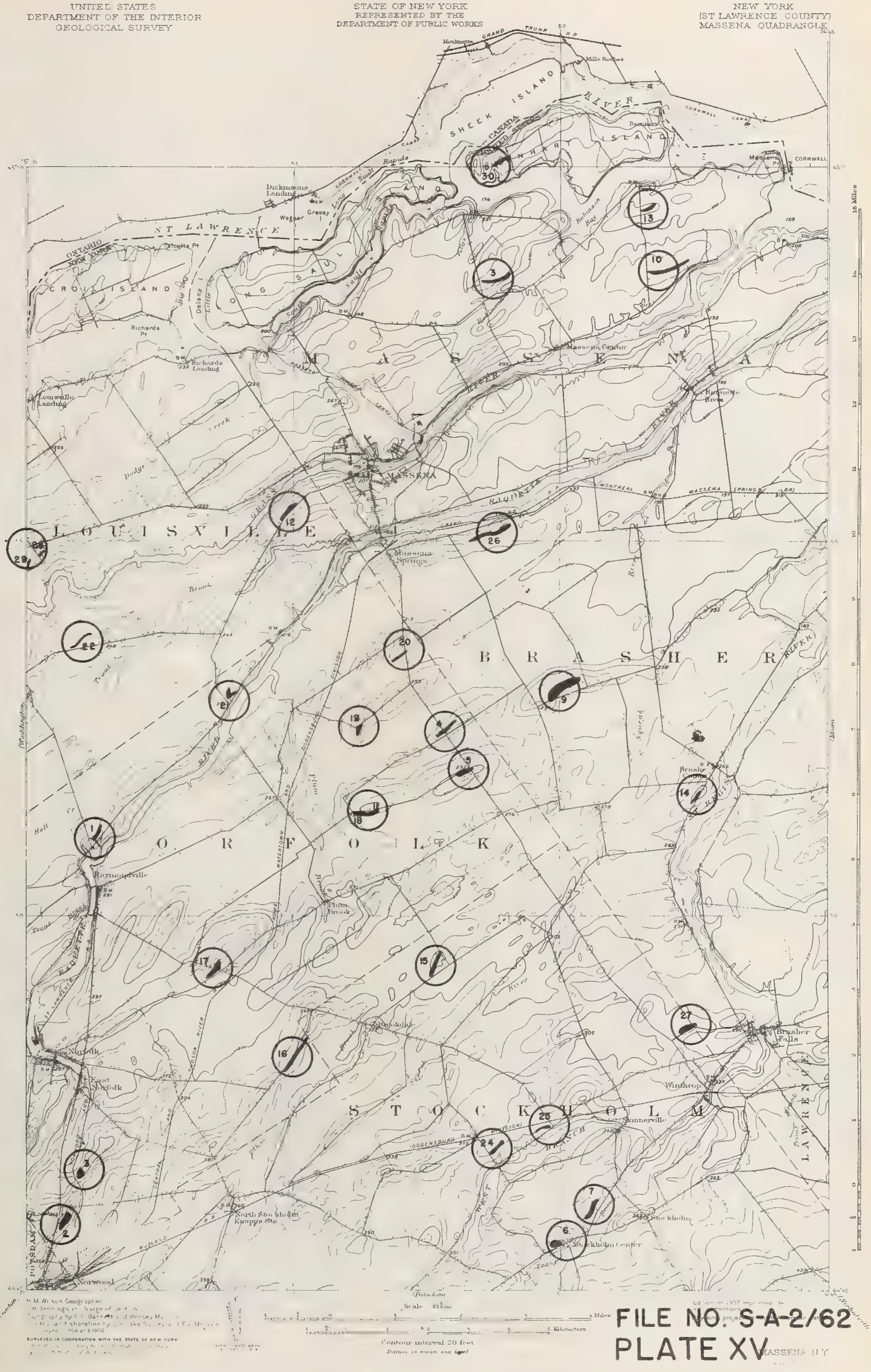
FILE NO. S-A-2/60

PLATE XIII

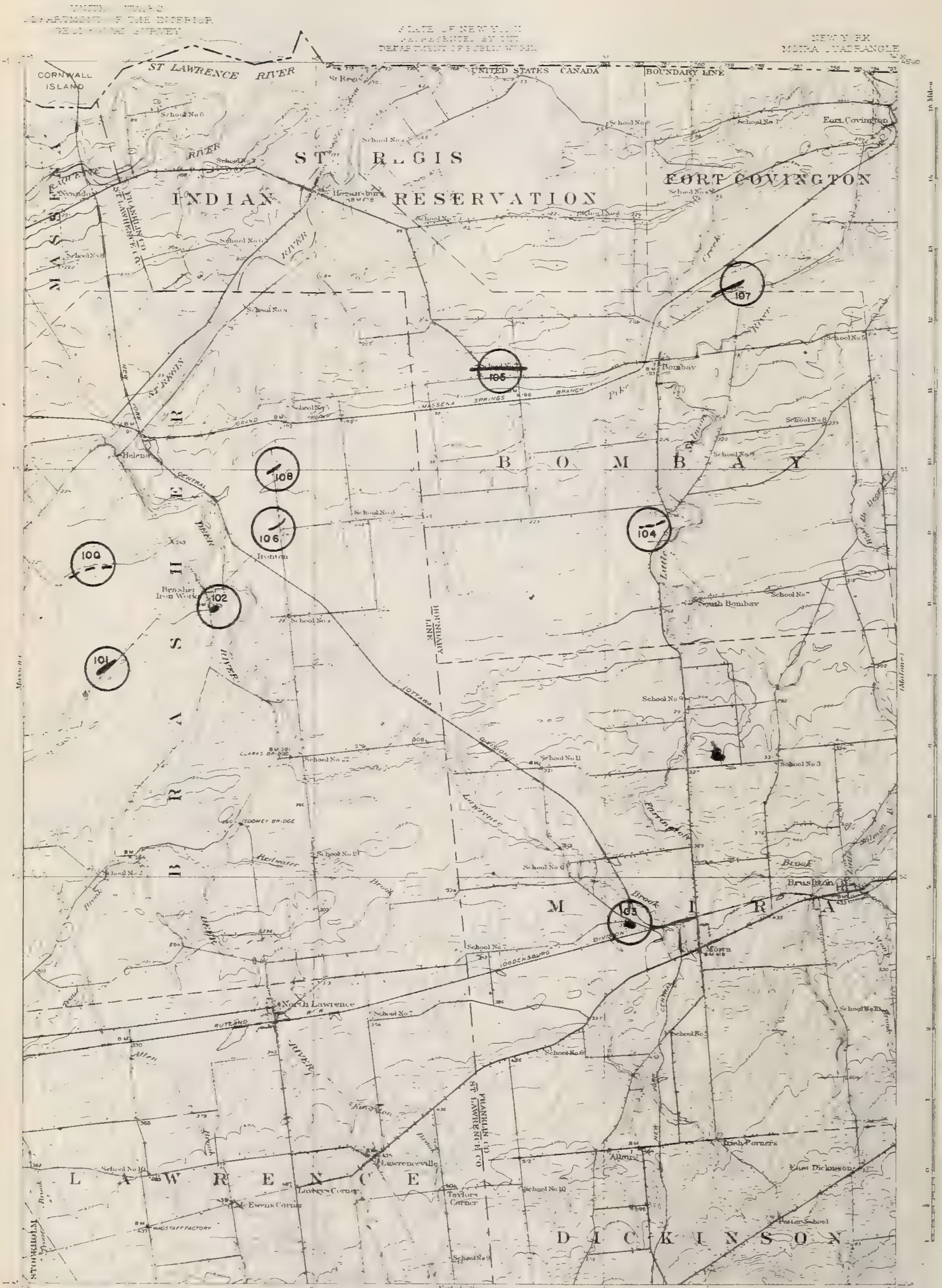


FILE NO. S-A-2/61

PLATE XIV



FILE NO. S-A-2/62
PLATE XV



FILE NO. S-A-2/63
PLATE XVI

DEPARTMENT OF NATIONAL DEFENCE
GEOGRAPHICAL SECTION, GENERAL STAFF

NATIONAL TOPOGRAPHIC SERIES

CANADA, SHEET 31 B/13

(Brockville 31 B/12)

MERRICKVILLE

ONTARIO

Scale 1 mile to 1 inch or 1:63,360

Contour interval 25 Feet
All Elevations in Feet above Mean Sea Level

NOTE. Grid squares may be drawn on this map by joining the corresponding divisions shown along the outer border, this will provide a series of four mile squares which form a convenient system of reference. The numbers of the squares are also given along the outer border

REFERENCE

REFERENCE

FILE NO. S-A-2/64

PLATE XVII

NATIONAL TOPOGRAPHIC SERIES

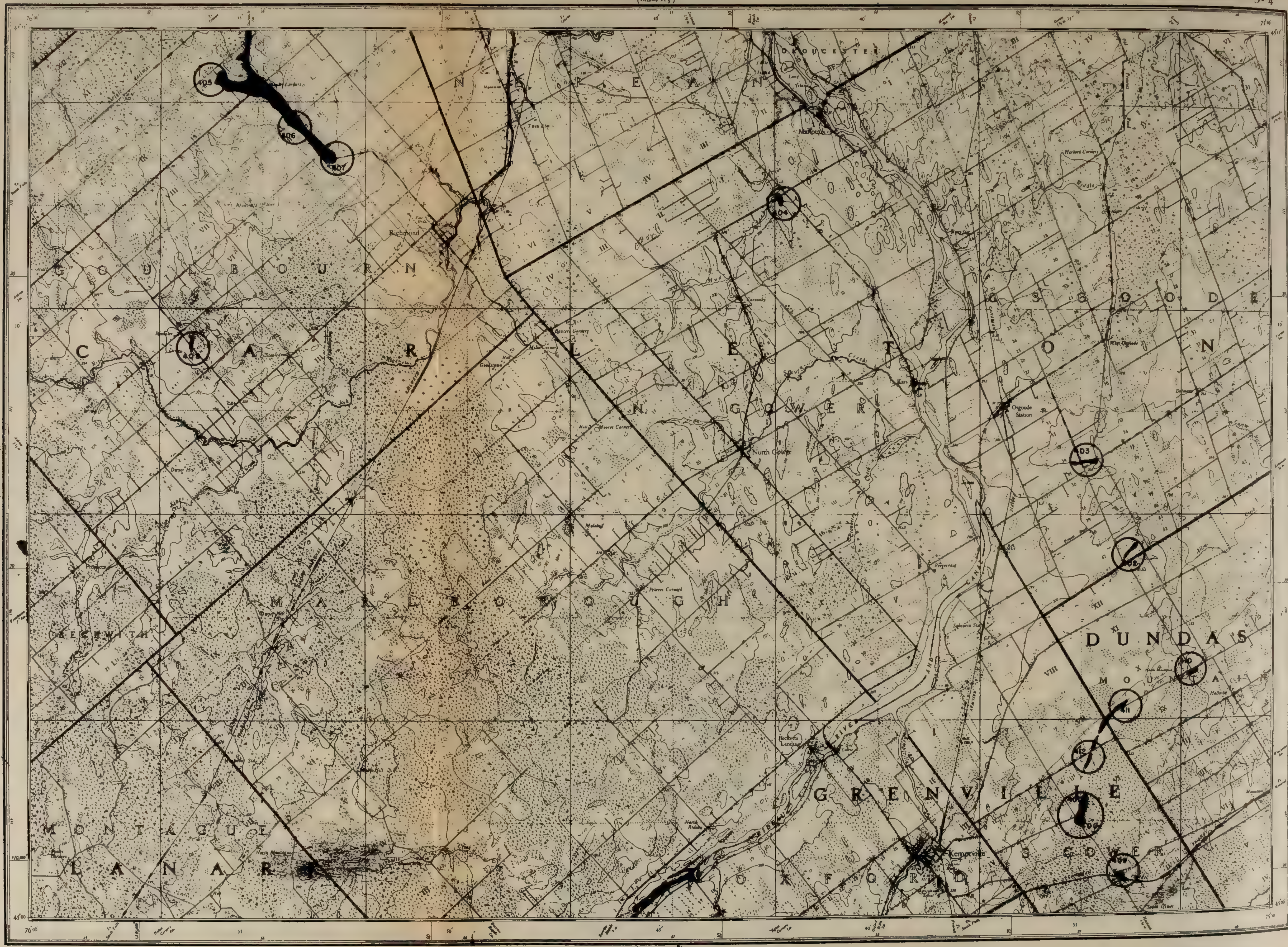
DEPARTMENT OF NATIONAL DEFENCE

HONOURABLE IAN A. MACKENZIE, P.C., M.A., LL.B., Minister

GEOGRAPHICAL SECTION, GENERAL STAFF

(Ottawa 31 G/5)

CANADA, SHEET 31 G/4



KEMPTVILLE

ONTARIO

Scale: One Inch to One Mile = 1/63360

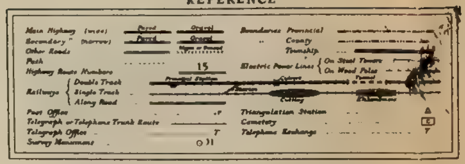
Contour Interval 25 Feet.

All Elevations in Feet above Mean Sea Level.

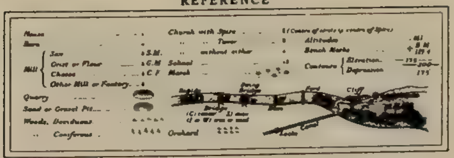
NOTE: The grid squares, four miles to a side, provide a ready method of referring to or locating features. Four squares are shown within the solid lines and only the even squares are numbered in the margin. The east and west sides of the squares are not true north and south lines, but have a deflection to the east varying from due north on the west side of the map to 0°21' on the east side. Any square is identified by the numbers along the outer border, for example Mountain will be found in square 54-171.

Surveyed and Reproduced by the Geographical Section, General Staff
DEPARTMENT OF NATIONAL DEFENCE.
Original Survey 1906
Resurveyed 1934
Reprinted 1938
Magnetic Declination 13°05' W. at North Gower 1936

REFERENCE



REFERENCE



Copies of these maps may be obtained from the Surveyor General, Department of the Interior, Ottawa. Price 25 cents.

FILE NO. S-A-2/65

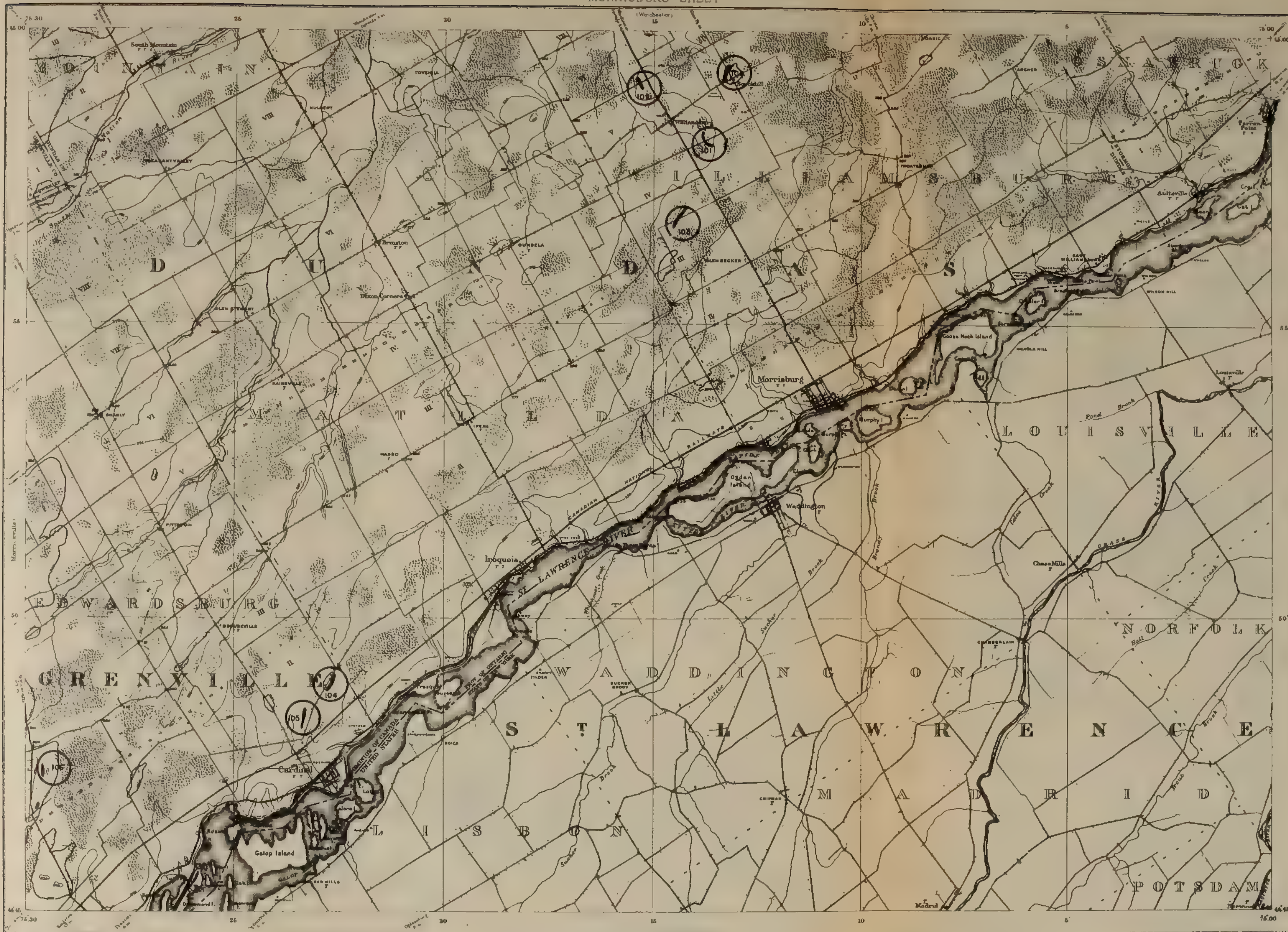
PLATE XVIII

TOPOGRAPHIC MAP

CANADA 1 INCH TO 1 MILE

ONTARIO

MORRISBURG SHEET



Department of National Defence
Reprinted with corrections 1926

Magnetic Declination 12°15' W at Morrisburg Aug 1923
Polyconic Projection
Elevations in feet above Mean Sea Level
Surveyed in 1905
Portion of United States taken from U.S. Geological Survey

Scale 1/63360 or 1 Inch to 1 Mile

Contour interval 25 Feet.

ONTARIO 75°00'-44°45'
MORRISBURG SHEET
No 9

FILE NO. S-A-2/66

PLATE XIX

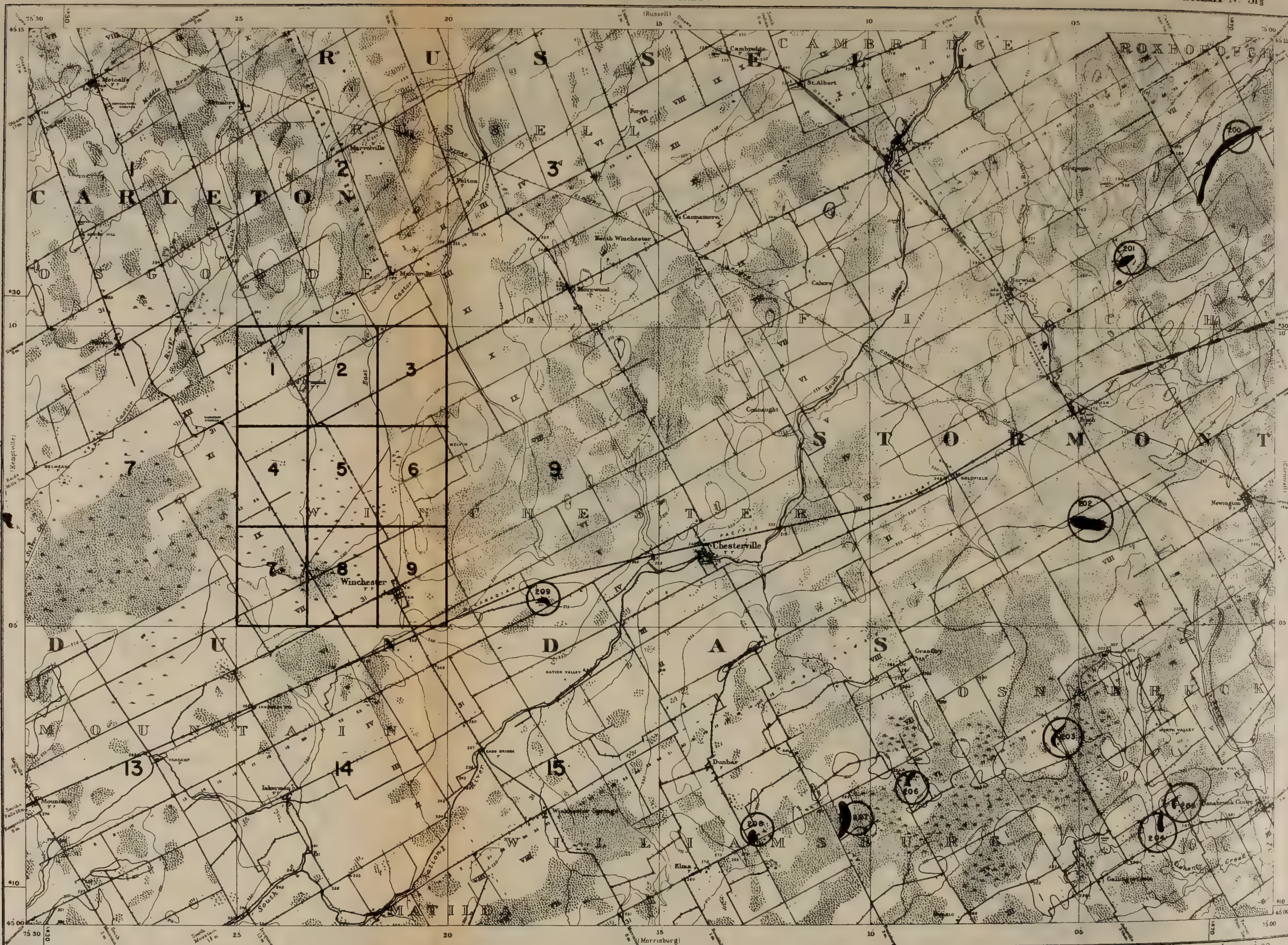
TOPOGRAPHIC MAP

ONTARIO

WINCHESTER SHEET

CANADA 1 INCH TO 1 MILE

SHEET No 31$\frac{G}{3}$



Published by the Geographical Section, General Staff
Department of National Defence 1909.
Reprinted 1933.

Magnetic Declination 13°38' W at Winchester, Jan 1933.
Polyconic Projection
Elevations in feet above Mean Sea Level
Surveyed in 1905 by the Geographical Section, G.S.

Scale 1/63360 or 1 Inch to 1 Mile

Contour interval 25 Feet

INDEX TO ADJOINING SHEETS

PRICE 25 CENTS

ONTARIO, 75 00 - 45 00

Highway Routes ... 31etc

FILE NO. S-A-2/67

PLATE XX

NATIONAL TOPOGRAPHIC SERIES

DEPARTMENT OF NATIONAL DEFENCE
HONOURABLE IAN A MACKENZIE, P.C., M.A., LL.B., Minister
GEOGRAPHICAL SECTION, GENERAL STAFF
(Alexandria 31 G/7)

CANADA, SHEET 31 G/2

U.S.E.D
APR 14 1944

CORNWALL

ONTARIO - QUEBEC

Scale: One Inch to One Mile = 1/63,360

Contour Interval 25 Feet.

FILE NO. S-A-2/68 PLATE XXI

CANADA 1 INCH TO 1 MILE

TOPOGRAPHIC MAP

QUEBEC – ONTARIO

HUNTINGDON SHEET

SHEET Nº 31 G/1

Published by the Geographical Section General Staff
Department of National Defence 1909
Revised 1935

International Boundary and adjacent topography from International Boundary Commission

Magnetic Declination 14°27' W Huntingdon Dec 1934.
Polyconic Projection
Elevations in feet above Mean Sea Level
Surveyed in 1907 by the Geographical Section, G.S.

Scale of 1 Inch to 1 Mile

Contour interval 25 Feet

INDEX TO ADJOINING SHEETS

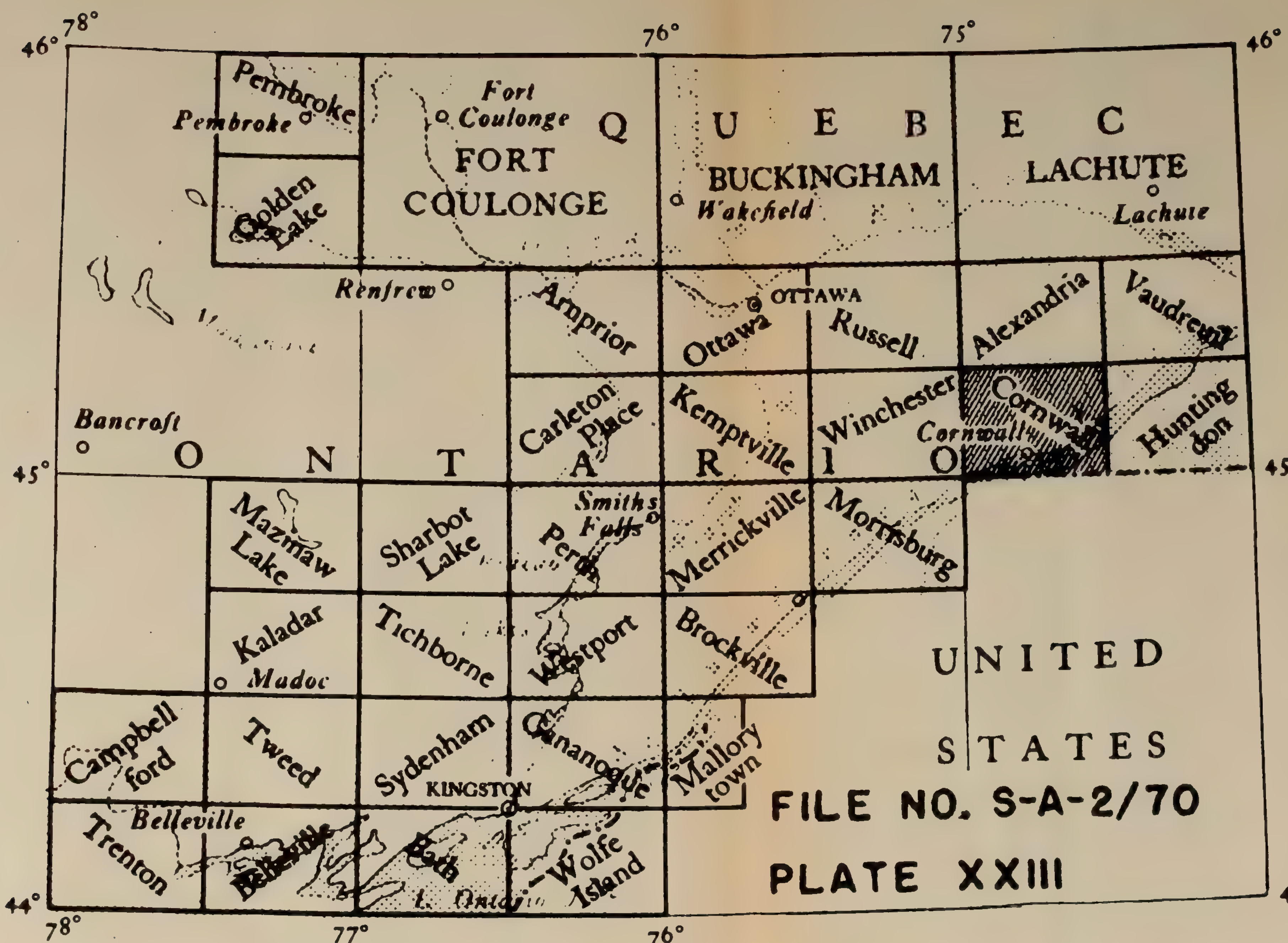
PRICE 25 CENTS

ONTARIO – QUEBEC 74°00'–45°00'

Highway Routes 2, etc

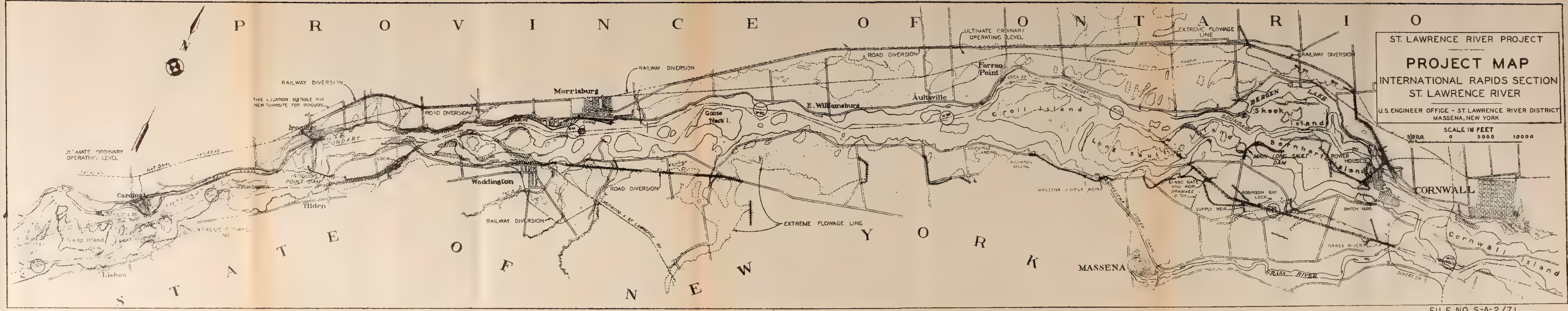
FILE NO. S-A-2/69

PLATE XXII



FILE NO. S-A-2/70

PLATE XXIII



FILE NO S-A-2/71
PLATE XXIV

Complete Field Inspection Reports for Each Deposit Visited

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9 x

Location on U. S. Quadrangles
Red Mills Quadrangle

Quadrangle Red Mills Pit 800 U. S. ~~or Canada~~ 9-9

Location of Deposit 5 miles southwest of Rockway Point on Sucker Brook

Name of Owner R. R. Armstrong

Transportation Facilities Approximately 6 miles by road to Rockway Point
Existing Exposure: Description of Pit Large 2 story pit-Pit is stepped in two 15' faces.

Mat'l removed 7,000 cu. yds. Working face 30' feet
Equipment in pit None
Projects furnished Local blacktop roads
Description of mat'l Ranges from clay to coarse gravel. Material fairly clean. Few shells. Material stratified with numerous silt and clay lenses.
Shale or rotten stone Trace Est.gravel/sand ratio 40/60
Gradation of SAND Good Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 10-15 % dry wt.
Est. % of stone over 6" 3-5 % vol.

Sampling: 100 lb. bag taken chiefly in the sand as the gravel % is not high.
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large, well developed-clearly stratified ranging from silt & Clay lenses to strata of coarse gravel.

Est. Quantity 80,000 cu. yds. Est. Max. Working face 30 feet

Inspector's Recommendations: 10 pits necessary for extent of deposit

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/72

D.O. Form No. 85

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9x

Location on U. S. Quadrangles
Red Mills Quadrangle

Quadrangle Red Mills Pit 801 U. S. ~~or Canada~~ 9-3

Location of Deposit 2½ miles southeast of Rockway Point

Name of Owner F. C. Dunn

Transportation Facilities 2½ miles by road to Rockway Point

Existing Exposure: Description of Pit Very small pit apparently old. Considerable slumping on face. Trench necessary to obtain sample

Mat'l removed 3,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads & form concrete
Description of mat'l Stratified, clean, well graded fine to coarse sand. Small % of well graded fine to medium gravel. Few shells.

Shale or rotten stone Trace Est.gravel/sand ratio 30/70
Gradation of SAND Good Gradation of GRAVEL Good
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 100 lb. bag sample from trench cut into old face

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, well formed beach resting on the adjacent till hill.

Est. Quantity 60,000 cu. yds. Est. Max. Working face 12' feet

Inspector's Recommendations: 10 pits necessary for limits of deposit

Date 8/25/41 Signed M. J. Verville

File No. S-A-2/73

D.O. Form No. 55

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9 x

Location on U. S. Quadrangles
Red Mills Quadrangle

Quadrangle Red Mills Pit 802 U. S. ~~or Canada~~ 9-3

Location of Deposit 2 miles southeast of Rockway Point

Name of Owner Frank Hunter opposite pit

Transportation Facilities $2\frac{1}{2}$ miles by road from Iroquois Dam site
Existing Exposure: Description of Pit Large well worked pit with small amount of stone over 1'. Pit apparently resting on till floor.

Mat'l removed 20,000 cu. yds. Working face 25 feet
Equipment in pit Small crusher jaw
Projects furnished Local dirt and black top roads
Description of mat'l Apparently well graded sedimentary stone sand, relatively clean. Material ranges from fine sand to 1' and 2' boulders. Few shells.
Shale or rotten stone trace Est. gravel/sand ratio 50/50
Gradation of SAND Good Gradation of GRAVEL Good
Est. % of silt of mat'l passing 1/4" 3-8 % dry wt.
Est. % of stone over 6" 3-5 % vol.

Sampling: 100 lb. bag sample from working face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description
Fairly large, well developed, resting on till floor exposed on bottom of pit.

Est. Quantity 50,000 cu. yds. Est. Max. Working face 25 feet

Inspector's Recommendations: 10 test pits necessary to determine extent

Date 9/2/41 Signed M. J. Verville

File No. S-A-2/74

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 700 U. S. ~~or Canada~~ 3-4

Location of Deposit 2½ miles east of Chase Mills

Name of Owner M. McCullough

Transportation Facilities Truck

Existing Exposure: Description of Pit
No pit open

Mat'l removed None cu. yds. Working face - feet
Equipment in pit -
Projects furnished -
Description of mat'l -

Shale or rotten stone - Est.gravel/sand ratio -
Gradation of SAND - Gradation of GRAVEL -
Est. % of silt of mat'l passing 1/4" % dry wt.
Est. % of stone over 6" % vol.

Sampling: None
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit approx. 400 yds. along with a possibility of 30,000 cu. yds.

Est. Quantity 30,000? cu. yds. Est. Max. Working face - feet

Inspector's Recommendations: 10 or 12 test pits necessary for estimate on extent.

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/75

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4 x	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 701 U. S. ~~xxxxxx~~ 4-8

Location of Deposit $1\frac{1}{2}$ miles southwest of Waddington

Name of Owner

Transportation Facilities Truck

Existing Exposure: Description of Pit Very shallow, very dirty material

Mat'l removed 7,000 cu. yds. Working face 9 feet
Equipment in pit None
Projects furnished road fill
Description of mat'l Material verty dirty and bouldery

Shale or rotten stone little Est.gravel/sand ratio 45/55
Gradation of SAND fair Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 10-12 % dry wt.
Est. % of stone over 6" 10-15% % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very shallow, small deposit

Est. Quantity limited cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Material too silty for any use but fill material. Test pits not believed necessary.

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/76

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 702 U. S. ~~Canada~~ 8-9

Location of Deposit 1¼ miles northeast of Madrid, east of Grass River

Name of Owner

Transportation Facilities Truck

Existing Exposure: Description of Pit Very small local road borrow pit

Mat'l removed 1,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Material fairly well graded few piles of boulders in pit

Shale or rotten stone little Est. gravel/sand ratio 40/60
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.
Est. % of stone over 6" 5-10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit very superficial

Est. Quantity limited cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Deposit is not large enough to be considered for further exploration, because of the distance from the project.

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/77

D.O. Form No. 36

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9 x

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 703 U. S. ~~Canada~~ 9-2

Location of Deposit 3 miles southeast of Chase Mills

Name of Owner

Transportation Facilities Truck

Existing Exposure: Description of Pit Fairly large pit, well worked and clean

Mat'l removed 10,000 cu. yds. Working face 12 feet

Equipment in pit None

Projects furnished All local roads and local farm use

Description of mat'l Material well graded, but contains considerable silt and very little gravel. Gravel platey.

Shale or rotten stone little Est. gravel/sand ratio 20/80

Gradation of SAND fair Gradation of GRAVEL Poor

Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.

Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly well developed marine beach, slightly stratified.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Expansion of pit doubtful because of farm house and buildings at end of pit. Road limits on other side. No. exploration is believed necessary.

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/78

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 704 U. S. or Canada 7-5

Location of Deposit 5½ miles south of Waddington, near Chipman

Name of Owner

Transportation Facilities Truck

Existing Exposure: Description of Pit Very small, superficial

Mat'l removed ______ cu. yds. Working face ______ feet

Equipment in pit

Projects furnished

Description of mat'l

Shale or rotten stone ______ Est. gravel/sand ratio

Gradation of SAND ______ Gradation of GRAVEL

Est. % of silt of mat'l passing 1/4" ______ % dry wt.

Est. % of stone over 6" ______ % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ______ Description

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations:

Date ______ Signed

File No. S-A-2/79

D.O. Form No. 85

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	x 6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Waddington Quadrangle

Quadrangle Waddington Pit 705 U. S. or Canada 6-1

Location of Deposit 1½ miles west of Louisville on Chase Mills Road

Name of Owner

Transportation Facilities Truck
Existing Exposure: Description of Pit Very small road borrow pit. Numerous very large boulders. Part of till ridge underlying gravel also used.

Mat'l removed 500 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Material very heavy in gravel and large boulders. Sand uniform.

Shale or rotten stone little Est. gravel/sand ratio 60/40
Gradation of SAND Poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.
Est. % of stone over 6" 15%-20% % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description Poorly developed deposit. Expansion of present pit limited by cemetery.

Est. Quantity limited cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Because of cemetery and nature of material no further investigation is believed necessary.

Date 7/16/41 Signed M. J. Verville

File No. S-A-2/80
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Quadrangle

Quadrangle Waddington Pit 706 U. S. ~~or Canada~~ 8-3

Location of Deposit

Name of Owner

Transportation Facilities

Existing Exposure: Description of Pit

Mat'l removed ____ cu. yds. Working face ____ feet

Equipment in pit

Projects furnished

Description of mat'l

Shale or rotten stone ____ Est. gravel/sand ratio

Gradation of SAND ____ Gradation of GRAVEL

Est. % of silt of mat'l passing 1/4" ____ % dry wt.

Est. % of stone over 6" ____ % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ____ Description

Est. Quantity ____ cu. yds. Est. Max. Working face ____ feet

Inspector's Recommendations:

Date ____ Signed

File No. S-A-2/81

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4 x	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massana Pit 1 U. S. or Canada

Location of Deposit 1 ml. N of town of Raymondville

Name of Owner Lee Whitaker

Transportation Facilities On St. Hwy 56

Existing Exposure: Description of Pit Large pit, numerous large boulders in pit. Pit in two steps. The upper part being very coarse. Till now exposed on floor of pit.

Mat'l removed 14,000 cu. yds. Working face 20 feet

Equipment in pit LIMA 1 yd. shovel - not owned by Whitaker

Projects furnished Fill for new Raymondville Road & local road material.

Description of mat'l Material quite silty and contains numerous boulders Lower 5' of 20' face, chiefly f. to c. SAND

Shale or rotten stone little Est. gravel/sand ratio 50/50

Gradation of SAND fair Gradation of GRAVEL fair

Est. % of silt of mat'l passing 1/4" 8-14 % dry wt.

Est. % of stone over 6" 15 to 20 % vol.

Sampling: 1 100 lb. bag from face of pit

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, well developed deposit, material varying from boulder bar on top to stratified sands on till ridge floor

Est. Quantity 50,000 cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: Material appears suitable for any fill or backing material but too silty for filters. 10 test pits would be necessary for more accurate estimate of quantity

Date 6/27/41 Signed M. J. Verville

File No. S-A-2/82

D.O. Form No. 46

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7 x	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 2 U. S. or Canada 7-7

Location of Deposit 1 mile north of Norwood & ½ mile east of Highway 56

Name of Owner Northern Quarries, Inc., Norwood, N. Y.

Transportation Facilities Rail within ½ mile - Truck

Existing Exposure; Description of Pit Old pit fairly small, considerable boulders and rotten stone

Mat'l removed 600 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished None
Description of mat'l Apparently dirty and bouldery - Gravel disintegration high. Sand appears too fine for use as filter or fill, because of poor gradation
Shale or rotten stone Some Est. gravel/sand ratio 30/70
Gradation of SAND Poor Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 5-10 % dry wt.
Est. % of stone over 6" 3 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Relatively Small deposit, apparently poor material. Deposit appears thin over till ridge below

Est. Quantity small cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: No exploration necessary because of limited extent of deposit, and apparent poor gradation.

Date 6/6/41 Signed M. J. Verville

File No. S-A-2/83
D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7 x	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 3 U. S. or Canada 7-7

Location of Deposit 1-3/4 miles south of Norfolk

Name of Owner Norwood & St. Lawrence Railroad

Transportation Facilities Railroad runs through pit.
Existing Exposure: Description of Pit Large old pit with few piles of 6" stones left in pit. Few large 2' & 3' boulders. Pit shows 2 types of material. Upper 10' coarse and gravelly, lower 10' uniform f. to m. sand.

Mat'l removed 40,000 cu. yds. Working face 20 feet
Equipment in pit None
Projects furnished Concrete Bridge in 1912: Paper mills at Norwood.
Description of mat'l Material coarse in upper 10', considerable rotten stone in this zone. Lower part uniform fine to medium sand with scattered gravel.
Shale or rotten stone Considerable Est.gravel/sand ratio 50/50 - 25/75
Gradation of SAND Combined, fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 7 - 10 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: No samples taken because of variability of material in gradation and also quantity of rotten stone.
(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Large, well developed feature. Now near exhaustion.

Est. Quantity 10,000 ? cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: From observation it is believed that the till ridge on which deposit is located is rising and may limit further deepening of pit. Gradation and rotten stone appears sufficient to warrant no further investigation.

Date 11/19/41 Signed M. J. Verville

File No. S-A-2/84

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5 x	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 4 U. S. ~~or Canada~~ 5-5

Location of Deposit 4 miles south of Massena on Winthrop Road

Name of Owner

Transportation Facilities Truck - on state highway 420, paved to Massena

Existing Exposure: Description of Pit Very small pit-shallow, poorly worked. Till exposed on floor of pit.

Mat'l removed 100 cu. yds. Working face 9 feet

Equipment in pit None

Projects furnished Probably local roads & local farm use.

Description of mat'l Material very dirty, poorly graded, very bouldery.

Shale or rotten stone Some Est. gravel/sand ratio 50/50

Gradation of SAND poor Gradation of GRAVEL fair

Est. % of silt of mat'l passing 1/4" % dry wt.

Est. % of stone over 6" % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly small; poorly formed and poorly developed beach. Material not well graded.

Est. Quantity 5,000 cu. yds. Est. Max. Working Face 10 feet

Inspector's Recommendations: No further preliminary exploration is believed necessary because of apperent limitations of deposit.

Date 5/5/41 Signed M. J. Verville

File No. S-A-2/85

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5 x	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 5 U. S. ~~or Canada~~ 5-5

Location of Deposit 5 miles south of Massena on Winthrop Road

Name of Owner

Transportation Facilities Truck - on State Highway 420 - Winthrop Road.
Existing Exposure: Description of Pit Pit very small only worked by shovel.

Mat'l removed Small cu. yds. Working face 3 feet
Equipment in pit None
Projects furnished
Description of mat'l Very dirty, poorly graded. Material apparently partly reworked till.

Shale or rotten stone little Est. gravel/sand ratio
Gradation of SAND poor Gradation of GRAVEL poor
Est. % of silt of mat'l passing 1/4" 10-12 % dry wt.
Est. % of stone over 6" 8 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit very limited, small Marine beach, poorly developed.

Est. Quantity small cu. yds. Est. Max. Working face 6 feet

Inspector's Recommendations: Further exploration not believed necessary because of apparent poor gradation of material and apparent limitations of deposit

Date 5/5/41 Signed M. J. Verville

File No. S-A-2/86
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 6 U. S. ~~or Canada~~ 8-9

Location of Deposit STOCKHOLM CENTER

Name of Owner 14 miles

Transportation Facilities 14 miles. Truck haul on Highways 11 and 420.
Existing Exposure: Description of Pit Numerous large boulders that are too large for a crusher.

Mat'l removed 2,000 cu. yds. Working face ______ feet
Equipment in pit Small screening & crushing plant
Projects furnished ______
Description of mat'l Very bouldery and dirty. All boulders flat, platey and angular. Sand very dirty.

Shale or rotten stone Considerable Est. gravel/sand ratio 70/30
Gradation of SAND Poor Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 10 % dry wt.
Est. % of stone over 6" 20-30 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Large marine bar resting on till ridge. Deposit poorly developed, most of the fines being washed out.

Est. Quantity ______ cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: No further exploration believed necessary because of quantity of large stone and gradation of the sand.

Date 5/5/41 Signed M. L. Vanville

File No. S-A-2/87

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

x

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 7 U. S. ~~or Canada~~ 9-7

Location of Deposit Approximately 3/4 miles northest of Stockholm Center

Name of Owner F. G. Fletcher, Norwood, N. Y.

Transportation Facilities 14 mile truck haul on Highways 11 & 420
Existing Exposure: Description of Pit Many piles of boulders to 4" stone in pit. Pit fairly large - Further expansion doubtful because of till ridge rising fairly close to surface.

Mat'l removed 10,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Road surfacing - Gymnasium in Winthrop
Description of mat'l Material dirty with poorly graded sand and gravel. Sand too fine.

Shale or rotten stone Some Est. gravel/sand ratio 40/60
Gradation of SAND Poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 10 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 cu. ft. of pit run.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large deposit- Considerable material removed.

Est. Quantity cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Because of distance from projects and nature of material, it is not recommended that further exploration be conducted.

Date 6/6/41 Signed M. J. Verville

File No. S-A-2/88
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
x 7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 8 U. S. ~~or Canada~~ 7-4

Location of Deposit ______

Name of Owner ______

Transportation Facilities ______
Existing Exposure: Description of Pit ______

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit ______
Projects furnished ______
Description of mat'l ______

Shale or rotten stone ______ Est. gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing 1/4" ______ % dry wt.
Est. % of stone over 6" ______ % vol. ______

QUARRY

Sampling: ______

QUARRY (See attached sheet for test results)

Nature of Deposit: Type ______ Description ______

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: ______

Date ______ Signed ______

File No. S-A-2/89

D. O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5 x	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 9 U. S. or Canada 5-6

Location of Deposit 5 miles southeast of Massena

Name of Owner Premo

Transportation Facilities Truck haul on 3 miles of dirt road to highway 420

Existing Exposure: Description of Pit Large, well worked, now apparently operating. New pit being developed. Encountered till in old pit.

Mat'l removed 50,000 cu. yds. Working face 15 feet
Equipment in pit Screen, crusher & washing plant.
Projects furnished Most of Massena's town work and Aluminum Co.
Description of mat'l Material fairly clean, fairly well graded. Sand & gravel, numerous shells.

Shale or rotten stone little Est. gravel/sand ratio 40/60
Gradation of SAND Good Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: Several cu. ft. boxes from all sides of pit. Few bag samples of processed material.
(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description Well developed. Long marine beach. Deposit variable and stratified.

Est. Quantity 250,000 cu. yds. Est. Max. Working face 30 feet

Inspector's Recommendations: 12 test pits necessary to prove deposit - This includes the Tyo pit which is on the northwest end of deposit.

Date 6/25/41 Signed M. J. Verville

File No. S-A82/90

[illegible]

St. Lawrance River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	x 3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 10 U. S. ~~or Canada~~ 3-2

Location of Deposit 2½ miles northeast of Massena Center

Name of Owner Aluminum Co. of America

Transportation Facilities Truck haul on gravel road to Hawkins Point.
Existing Exposure: Description of Pit Pit very shallow and small, only small amount of material removed. Apparently resting on till floor - water standing in east end of it.

Mat'l removed 500 cu. yds. Working face 3 to 4 feet
Equipment in pit None
Projects furnished Aluminum Co. of America
Description of mat'l Material shows a fair graded sand and poorly graded gravel with the material fairly clean.

Shale or rotten stone little Est. gravel/sand ratio 30/70
Gradation of SAND fair Gradation of GRAVEL poor
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: Sample taken by H. A. Verville in March 1941

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit appears variable and possibly a very shallow deposit.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: 10 test pits necessary to prove extent and depth. Because of convenient location to project further exploration may be advised

Date 6/25/41 Signed M. J. Verville

File No. S-A-2/91

D. O. Form No. 66

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 11 U. S. ~~or Canada~~ 5-5

Location of Deposit $6\frac{1}{2}$ miles south of Massena, $1\frac{1}{2}$ miles west of Winthrop Road

Name of Owner Walter Hartford lives opposite pit

Transportation Facilities Truck haul on paved road to state highway 420.

Existing Exposure: Description of Pit Fairly large well worked clean pit, now operating

Mat'l removed 12,000 cu. yds. Working face 15 feet

Equipment in pit None

Projects furnished Local roads as fill and surface material

Description of mat'l Material clean, sound. Very well graded with only very few shells.

Shale or rotten stone Trace Est.gravel/sand ratio 35/65

Gradation of SAND Good Gradation of GRAVEL Good

Est. % of silt of mat'l passing 1/4" 1 - 3 % dry wt.

Est. % of stone over 6" 1 - 2 % vol.

Sampling: 2 cu. ft. boxes taken from face

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very well formed long beach. Pit No. 18 in same deposit on west end. Deposit apparently extensive.

Est. Quantity 80,000 cu. yds. Est. Max. Working face 15' feet

Inspector's Recommendations: 12 test pits necessary to prove extent and depth. Material suitable for filters.

Date 6/25/41 Signed M. J. Verville

File No. S-A-2/92

B.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1 x	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 12 U. S. ~~or Canada~~ 1-9

Location of Deposit 1½ miles west of Massena on Andrew's Street

Name of Owner W. Manning, 158 Maple Street, Massena, N. Y.

Transportation Facilities 1½ mile truck haul on concrete roads, Highway 56

Existing Exposure: Description of Pit Large well worked pit now operating Roughly stratified and variable. Considerable material removed. Lower 10' of pit composed of fine to c. sand, no gravel.

Mat'l removed 35,000 cu. yds. Working face 30 feet
Equipment in pit None
Projects furnished Hogensburg, Massena Highway & local roads.
Description of mat'l Material stratified with a fair sand & gravel gradation. Few shells.

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.
Est. % of stone over 6" 8-10 % vol.

Sampling: 1 rep. bag of sand - 1 cu. ft. of gravel & sand
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Long well developed beach - variable - stratified. Deposit nearly exhausted.

Est. Quantity 8,000 to 10,000 cu. yds. Est. Max. Working face 30 feet

Inspector's Recommendations: Any work done in this pit would necessitate a scraping process, as the existing pit is badly broken up into smaller pits. Few test pits necessary to prove extent. Because of apparent limitations no further exploration is recommended.

Date 6/25/41 Signed M. J. Verville

File No. S-A-2/93

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	x 3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 13 U. S. ~~or Canada~~ 3-2

Location of Deposit 3/4 mile southwest of Hawkins Point

Name of Owner

Transportation Facilities Truck haul for ½ mile to River Road

Existing Exposure: Description of Pit Dike foundation test pit No. T920 only information available.

Mat'l removed cu. yds. Working face feet
Equipment in pit
Projects furnished
Description of mat'l Material apparently fairly clean with numerous shells.

Shale or rotten stone little Est. gravel/sand ratio
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" % dry wt.
Est. % of stone over 6" % vol.

Sampling: Few bag samples

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Apparently a fairly limited deposit. Depth very questionable.

Est. Quantity limited cu. yds. Est. Max. Working face feet

Inspector's Recommendations: 12 test pits necessary to prove extent. Material appears suitable as road materials or backing.

Date 6/25/41 Signed M. J. Verville

File No. S-A-2/94

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 14 U. S. ~~or Canada~~ 6-8

Location of Deposit ½ mile southwest of Brasher Center

Name of Owner William Sullivan, R.F.D.#2, Brasher Center

Transportation Facilities Truck haul on black top road to Helena or Brasher
Existing Exposure: Description of Pit Very large pit. Considerable blow sand - Deposit variable. Ranging from blow sand through good sand & gravel to till. Good material mostly removed.

Mat'l removed 30,000 cu. yds. Working face 15 feet
Equipment in pit None
Projects furnished Black top road from Helena to Brasher Falls
Description of mat'l Material fine blow sand in some parts of pit and very dirty and plately gravel in other parts.

Shale or rotten stone Considerable Est. gravel/sand ratio 40/60
Gradation of SAND Variable Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.
Est. % of stone over 6" 5-10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit chiefly marine beach with a blow sand cap.

Est. Quantity 80,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: No further exploration necessary as material appears poor for any use except fill, and more suitable deposits are closer to the job.

Date 6/25/41 Signed M. J. Verville

File No. S-A-2/95

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 15 U. S. ~~xxx~~Grids 8-2

Location of Deposit 1½ miles northwest of Brookdale

Name of Owner Andrew Brothers

Transportation Facilities Truck haul for 3 miles on dirt road to Massena-Winthrop road

Existing Exposure: Description of Pit Small poor pit. Considerable boulders and dirty material. Considerable boulders left in bottom of pit. Till ridge rising to surface on floor of pit.

Mat'l removed 8,000 cu. yds. Working face 9 feet
Equipment in pit None
Projects furnished Local roads as fill
Description of mat'l Material very dirty with abundence of large boulders and flat slab gravel.

Shale or rotten stone Considerable Est. gravel/sand ratio 40/60
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 5-10 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Glacial End Moraine Description Low ridge composed of very dirty variable material.

Est. Quantity 30,000 cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Material too dirty and platey for any use except fill material. No further exploration believed necessary.

Date 6/26/41 Signed M. J. Verville

File No. S-A-2/96

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7 x	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 16 U. S. ~~or Canada~~ 7-6

Location of Deposit 1½ miles southwest of Brookdale & 9 miles from Massena

Name of Owner Mark Mohoney

Transportation Facilities Truck haul on dirt road for 1 mile-then pavement into Raymondville

Existing Exposure: Description of Pit Large pit made up of several smaller pit. All material over 4" left in pit. Numerous piles of boulders in pit.

Mat'l removed 12,000 cu. yds. Working face 15 feet
Equipment in pit None
Projects furnished All local gravel and surfaced roads.
Description of mat'l Material is fairly well graded, slightly dirty and contains few shells. Material ranges from silt to Material slightly stratified. Material well rounded.
Shale or rotten stone little Est. gravel/sand ratio 30/70
Gradation of SAND Good Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" 10% % vol.

Sampling: 1 cu. ft. box sample taken from face of pit
(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Very long well developed bar. Material poorly stratified.

Est. Quantity 80,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: 8 test pits necessary to prove extent of deposit. Further test pitting may prove a large quantity. Material suitable for road and backing material.

Date 6/26/41 Signed M. J. Verville

File No. S-A-2/97

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	x 1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 17 U. S. ~~or Canada~~ 7-3

Location of Deposit 3½ miles southeast of Raymondville

Name of Owner Jacob Walker

Transportation Facilities ½ mile from railroad, 2 mile truck haul on paved road to Raymondville

Existing Exposure: Description of Pit shallow, wide pit apparently resting on till floor. Would require a stripping operation.

Mat'l removed 8,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local gravel and surfaced roads
Description of mat'l Material is fairly well graded sand & Gravel but is fairly dirty.

Shale or rotten stone little Est. gravel/sand ratio 30/70
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.
Est. % of stone over 6" 3-5 % vol.

Sampling: 1 cu. ft. box from trench cut into face of pit

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large in extent but very shallow in depth.

Est. Quantity 20,000 cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: 8 to 12 test pits necessary to prove both extent and depth of deposit. Depth very questionable.

Date 6/26/41 Signed M. J. Verville

File No. S-A-2/98

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5 x	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 18 U. S. ~~Canada~~ 5-7

Location of Deposit 600 yds. west of Hartford Pit in same deposit.

Name of Owner William Oaks

Transportation Facilities 2 mile truck haul on paved road to Massena-Winthrop Road

Existing Exposure: Description of Pit Same as 11 - clean fairly large well worked pit. Till possibly exposed on floor of pit.

Mat'l removed 10,000 cu. yds. Working face 12 feet
Equipment in pit Old shovel, foundation for screening plant
Projects furnished Local roads as surface and fill.
Description of mat'l Same as 11 - clean, sound, well graded with only few shells.

Shale or rotten stone Trace Est. gravel/sand ratio 35/65
Gradation of SAND Good Gradation of GRAVEL Good
Est. % of silt of mat'l passing 1/4" 2-3 % dry wt.
Est. % of stone over 6" 3 % vol.

Sampling: 1 cu. ft. box from face of pit
1 100 lb. bag from face of pit
(See attached sheet for test results)

Nature of Deposit: Type Description

Same as No. 11

Est. Quantity *160,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: The 12 pits to prove Hartford will prove this pit as they are in same deposit.

Date 6/26/41 Signed M. J. Verville

*This figure includes the Hartford Pit

File No. S-A-2/99

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	x 5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 19 U. S. ~~or Canada~~ 5-4

Location of Deposit $4\frac{1}{2}$ miles south of Massena

Name of Owner Homer Farnsworth

Transportation Facilities $\frac{1}{2}$ mile from railroad-$1\frac{1}{2}$ mile truck haul to Massena-Winthrop Roa

Existing Exposure: Description of Pit Very shallow pit resting on till floor. Pit runs heavy in gravel.

Mat'l removed 2,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Material fairly dirty with a fair gradation in both the sand & gravel.

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 5-10 % dry wt.
Est. % of stone over 6" 10%-12 % vol.

Sampling: 1 cu. ft. box from trench in face of pit

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very shallow deposit and limited on 2 sides by till. Extent doubtful.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 7 feet

Inspector's Recommendations: 7 or 8 pits necessary if deposit is to be proven. No exploration is recommended if more favorable sources are available, because till floor is very irregular and may very much limit the quantity.

Date 6/26/41 Signed M. J. Verville

File No. S-A-2/100

D.C. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	x 5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 20 U. S. ~~or Canada~~ 5-2

Location of Deposit 2 miles south of Massena Springs

Name of Owner Agnes Labarge, 11 South Street, Massena

Transportation Facilities Truck haul for ½ mile on dirt road to Winthrop Massena-Winthrop road

Existing Exposure: Description of Pit Fairly large well worked pit. 1½' of stripping necessary. Few piles of boulders in bottom of pit.

Mat'l removed 10,000 cu. yds. Working face 9' feet
Equipment in pit None
Projects furnished Used by Premo on Norfork Road & local roads.
Description of mat'l Deposit variable, fairly clean, few shells. Deposit stratified.

Shale or rotten stone little Est. gravel/sand ratio 40/60
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" 8-10 % vol.

Sampling: 1 cu. ft. box of pit run & 1 bag sample of some screened SAND.
(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Well developed feature. East end of deposit entirely used. stratified.

Est. Quantity 50,000 cu. yds. Est. Max. Working face 9' feet

Inspector's Recommendations: Deposit favorable because of closeness to job. 8 test pits necessary for more accurate estimate on extent.

Date 6/27/41 Signed M. J. Verville

File No. S-A-2/101

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4 x	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 21 U. S. ~~or Canada~~ 4-6

Location of Deposit $5\frac{1}{2}$ miles southwest of Massena on Raquette River Road

Name of Owner Dalbert Baxter

Transportation Facilities Truck haul on state highway 56

Existing Exposure: Description of Pit Fairly large pit resting on till floor. Numerous large 3' boulders scattered around pit. Apparently at water table level.

Mat'l removed 6,000 cu. yds. Working face 9 feet
Equipment in pit None
Projects furnished Local road fill
Description of mat'l Material fairly dirty with a fair gradation of sand & gravel. Numerous large 2' & 3' boulders.

Shale or rotten stone Considerable Est. gravel/sand ratio 50/50
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing 1/4" 5-10 % dry wt.
Est. % of stone over 6" 15 to 18 % vol.
5% over 1'

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large shallow deposit resting on till. Extent doubtful.

Est. Quantity 20,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Material suitable only for fill material. No further exploration is believed necessary as more suitable deposits are located closer to Massena.

Date 6/27/41 Signed M. J. Verville

File No. S-A-2/102

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
x 4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 22 U. S. ~~or Canada~~ 4-1

Location of Deposit 6 miles west of Massena on Trout Brook

Name of Owner Glen Wilson - lives next to pit

Transportation Facilities Truck on dirt road to State highway 56

Existing Exposure: Description of Pit Small pit comprised of a road cut. Pit not developed, only very small amount removed.

Mat'l removed 1,000 cu. yds. Working face 9 feet
Equipment in pit None
Projects furnished New adjacent road fill.
Description of mat'l Material fairly dirty with a fair gradation of both sand & Gravel. Deposit stratified. Few shells

Shale or rotten stone little Est. gravel/sand ratio 30/70
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 3 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: 1 cu. ft. box from face of trench.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit apparently large, well developed beach - stratified.

Est. Quantity 40,000? cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: 15 test pits necessary to determine more accurately the extent and nature of material. Deposit not developed.

Date 6/2?/41 Signed M. J. Verville

File No. S-A-2/103

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	x 6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 23 U. S. Square 6-4

Location of Deposit 1/4 mile east of Premo's Pit

Name of Owner John Tyo

Transportation Facilities 2 mile truck haul on gravel road to Massena-Winthrop road

Existing Exposure: Description of Pit Newly opened small pit, stratified, shallow. Apparently on till floor.

Mat'l removed 2,000 cu. yds. Working face 5 feet

Equipment in pit None

Projects furnished New road near pit as fill& surface

Description of mat'l Clean, fairly well graded, numerous shells. 1' clayey gravelly seam extending through pit, 6' below surface.

Shale or rotten stone Trace Est.gravel/sand ratio 30/70

Gradation of SAND fair Gradation of GRAVEL fair

Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.

Est. % of stone over 6" 3-5 % vol.

Sampling: 1, 100 lb. bag sample taken from trench cut into face of pit.

(See attached sheet for test results)

Nature of Deposit: Type Description

SAME AS PREMO'S

Est. Quantity* 250,000 cu. yds. Est. Max. Working face 30 feet

Inspector's Recommendations:

See Premo Pit No. 9

Date 6/25/41 Signed M. J. Verville

*This quantity includes Premo's pit and represents whole deposit

File No. S-A-2/104

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 24 U. S. or Canada 8-6

Location of Deposit 1½ miles northwest of Stockholm Center

Name of Owner Guy Munson

Transportation Facilities ¼ mile from railroad-3 mile truck haul to Massena-Winthrop Road

Existing Exposure: Description of Pit Pit very shallow, till floor rising close to gravel. Now operating

Mat'l removed 6,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads & railroad fill
Description of mat'l Material is fairly clean, with a fair gradation. Good material is very shallow.

Shale or rotten stone little Est. gravel/sand ratio 35/65
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.
Est. % of stone over 6" 3-7 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Limited very shallow deposit. Extent doubtful. Very superficial

Est. Quantity 15,000 cu. yds. Est. Max. Working face 9 feet

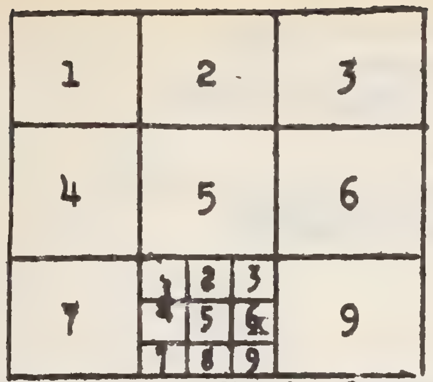
Inspector's Recommendations: Because of the apparent limitations of material. No exploration is believed necessary.

Date 6/30/41 Signed M. J. Verville

File No. S-A-2/105

D.O. Form No. 86

St. Lawrence River Project
Massena, N.Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT



Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 25 U. S. ~~or Canada~~ 8-6

Location of Deposit 2 miles west of Winthrop

Name of Owner Fred Munson

Transportation Facilities 1/8 mile from railroad, 3 mile truck haul to Massena-Winthrop Road

Existing Exposure: Description of Pit Small, very shallow, poorly worked. Till on floor of pit.

Mat'l removed 9,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local roads & railroad fill.
Description of mat'l Material fairly dirty with fair gradation of both sand & gravel. Considerable rotten stone.

Shale or rotten stone Considerable Est.gravel/sand ratio 35/65
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.
Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very limited in extent and depth.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 8 feet

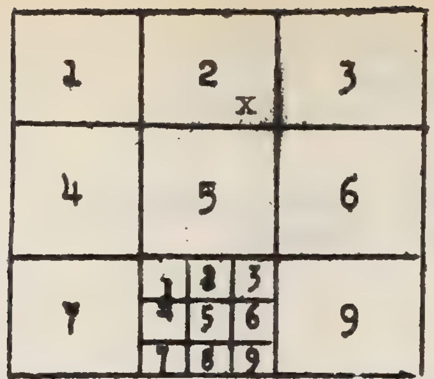
Inspector's Recommendations: Because of apparent limitations no exploration is believed necessary as more suitable material can be located closer to Massena.

Date 6/30/41 Signed M. J. Verville

File No. S-A-2/106

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT



Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 26 U. S. ~~xxxCanadax~~ 2-9

Location of Deposit 1-3/4 miles east of Massena Springs

Name of Owner Emery Baxter

Transportation Facilities 1-3/4 mile truck haul on newly paved Massena-Helena Road
Existing Exposure: Description of Pit Old, large, well developed pit. Considerable material removed. Apparently pit has been cut back to till. Not being worked. Pit nearly exhausted.

Mat'l removed 10,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished Massena Springs - Henena Road
Description of mat'l Material now dirty with numerous boulders. Few small pockets of fairly good material, numerous shells, occasional lenses of silt & Clay.
Shale or rotten stone little Est. gravel/sand ratio 45/55
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8 to 10 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: Several test pits excavated to prove deposit for airport investigations.
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large, well developed deposit. Now mostly exhausted.

Est. Quantity 5,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Further exploration not necessary because of obvious limitations of deposit.

Date 7/17/41 Signed M. J. Verville

File No. S-A-2/107

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	x 9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 27 U. S. ~~or~~ Canada 9-2

Location of Deposit 1 mile west of Brasher Falls

Name of Owner

Transportation Facilities Railroad 1 mile away-1 mile truck haul to Massena - Winthrop Road

Existing Exposure: Description of Pit Old test pit only exposure

Mat'l removed - cu. yds. Working face Probably 10 feet
Equipment in pit
Projects furnished
Description of mat'l Material fairly clean with fair gradation and few shells. Approximately 10% silt.

Shale or rotten stone little Est. gravel/sand ratio 60/40
Gradation of SAND Fair Gradation of GRAVEL Good
Est. % of silt of mat'l passing 1/4" 3 % dry wt.
Est. % of stone over 6" 20% % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Deposit apparently limited. Probably shallow

Est. Quantity limited cu. yds. Est. Max. Working face -10 feet

Inspector's Recommendations: No exploration is advised for this deposit because of apparent limited extent.

Date 8/25/41 Signed M. J. Verville

File No. S-A-2/108

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
x 4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 28 U. S. ~~or Canada~~ 4-1

Location of Deposit 6 miles west of Massena

Name of Owner John Badie

Transportation Facilities 1/4 mile truck haul to state highway 37

Existing Exposure: Description of Pit Old, large well developed pit. Numerous cobbles & boulders over floor & in piles around the pit. Pit now on till floor. Not operating

Mat'l removed 10,000 cu. yds. Working face 25 feet
Equipment in pit None
Projects furnished All local black top roads
Description of mat'l Material fairly dirty and having fair gradation with few shells. Numerous cobbles & boulders. Gravel has large amount of shale and rotten stone.
Shale or rotten stone Considerable Est. gravel/sand ratio 60/40
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 10 % dry wt.
Est. % of stone over 6" 15% % vol.
5% over 1'

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, deep well developed deposit. Quantity of material remaining doubtful.

Est. Quantity 8,000 to 10,000 cu. yds. Est. Max. Working face 25 feet

Inspector's Recommendations: Expansion of pit limited because of farm house. Material suitable for fill material but apparently unsuitable for filters. Exploration not advised unless Deposit 29 does not prove favorable. Further expansion doubtful because of farm buildings.

Date 9/2/41 Signed M. J. Verville

File No. S-A-2/109

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
x 4	5	6
7	8	9

1	2	3
4	5	6
7	8	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 29 U. S. or Canada 4-1

Location of Deposit 1½ miles northeast of Louisville

Name of Owner Fred Alexandia

Transportation Facilities Truck haul for ½ mile to state highway 37.

Existing Exposure: Description of Pit Fairly large shallow pit - clean well worked. Pit now being worked. Upper part of pit very bouldery and dirty. Lower 4' well graded sand & Gravel.

Mat'l removed 8,000 cu. yds. Working face 8' feet
Equipment in pit Screening & crushing plants
Projects furnished Local roads and local concrete
Description of mat'l fairly clean, /rotten stone, well graded sand.
Few shells. some

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 3-7 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: 100 lb. bag taken from face of pit.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Long, well formed low beach resting on till. Deposit variable.

Est. Quantity 25,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: 10 pits necessary for extent and depth of deposit. Favorable source of sand and gravel for any work in vicinity of Louisville Landing. Further exploration in form of test pits advised.

Date 9/2/41 Signed M. J. Verville

File No. S-A-2/110

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2 x	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 30 U. S. ~~[illegible]~~ 2-3

Location of Deposit West end of Barnhart Island

Name of Owner

Transportation Facilities Truck haul on dirt road to east end of Island.
Existing Exposure: Description of Pit Only 2 dike foundation pits.
T311p and T113p.

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit
Projects furnished
Description of mat'l Material fairly clean, fairly well graded.
Numerous shells.

Shale or rotten stone little Est.gravel/sand ratio
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing 1/4" 5 % dry wt.
Est. % of stone over 6" 5-8 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Apparently
fairly large beach over laying till ridge.

Est. Quantity ? cu. yds. Est. Max. Working face ? feet

Inspector's Recommendations: Because of the quantity of gravel needed on the island, further investigation of this deposit may be advised. It is recommended that 12-15 test pits be excavated in this deposit.

Date 10/8/41 Signed M. J. Verville

File No. S-A-2/111
D.O. Form No. 55

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2 x	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 31 U. S. ~~or Canada~~ 2-3

Location of Deposit On Horton Road near Polly's Creek

Name of Owner

Transportation Facilities 1 mile from river road

Existing Exposure: Description of Pit Only few foundation pits

Mat'l removed - cu. yds. Working face - feet

Equipment in pit -

Projects furnished -

Description of mat'l Fairly well graded sand & Gravel

Shale or rotten stone little Est.gravel/sand ratio -

Gradation of SAND Gradation of GRAVEL

Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.

Est. % of stone over 6" 5-10 % vol.

Sampling: Few rep bag samples taken from test pits. T248p and T252p

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large, well formed marine beach

Est. Quantity ? cu. yds. Est. Max. Working face feet

Inspector's Recommendations: Pit now being worked by Premo for Aluminum Co.

Date 11/19/41 Signed M. J. Verville

File No. S-A-2/112

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
x 4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 100 U. S. ~~[illegible]~~ 4-1

Location of Deposit 1-3/4 miles east of Brasher Iron Works

Name of Owner

Transportation Facilities 1½ mile truck haul on dirt road to black top Helena road

Existing Exposure: Description of Pit No existing pit, but a large area of blow or Dune sand with small pockets of gravel.

Mat'l removed - cu. yds. Working face - feet
Equipment in pit -
Projects furnished -
Description of mat'l Composed chiefly of dune sand of fine to med. sand with few pockets of poorly graded gravel.

Shale or rotten stone - Est. gravel/sand ratio Variable
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 3-7 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type dune Description Large area of wind blown sand.

Est. Quantity - cu. yds. Est. Max. Working face - feet

Inspector's Recommendations: No further exploration believed necessary because of gradation of material and also variability of pit. Any quantity of suitable material doubtful.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/113

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
x 4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 101 U. S. ~~or Canada~~ 4-4

Location of Deposit 1-3/4 miles southwest of Brasher Iron Works

Name of Owner -

Transportation Facilities 1½ mile haul by truck to blacktop Helena road
Existing Exposure: Description of Pit Small, shallow pit resting on till. Deposit nearly exhausted.

Mat'l removed 5,000 cu. yds. Working face 5 feet
Equipment in pit None
Projects furnished Local roads by C.C.C.
Description of mat'l Material fairly dirty with a fair gradation of sand and gravel. Considerable rotten stone

Shale or rotten stone Considerable Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 3-7 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Low isolated ridge protruding through dune sand and showing till on floor of pit.

Est. Quantity limited cu. yds. Est. Max. Working face 5 feet

Inspector's Recommendations: Because of limited quantity no further exploration is believed necessary. Blow sand is visiable on 4 sides of deposit. Deposit nearly exhausted.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/114

D.O. Form No. 36

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4 x	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 102 U. S. ~~Sector~~ 4-6

Location of Deposit Same as 101

Name of Owner

Transportation Facilities
Existing Exposure: Description of Pit

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit
Projects furnished
Description of mat'l

Shale or rotten stone ______ Est.gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing 1/4" 3-7 % dry wt.
Est. % of stone over 6" - % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ______ Description ______

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations:

Date ______ Signed M. J. Verville

File No. S-A-2/115

D.O. Form No. 66

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 x 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 103 U. S. ~~xxx~~Canada x 9-1

Location of Deposit Near railroad, 3/4 miles west of town of Moira

Name of Owner

Transportation Facilities Railroad 1/8 mile from pit.
Existing Exposure: Description of Pit Shallow, probably excavated to till floor. Pit nearly exhausted.

Mat'l removed 25,000 cu. yds. Working face 10 feet
Equipment in pit small screening plant
Projects furnished Most work done in Moira, roads & concrete
Description of mat'l Material fairly dirty, quite silty, fair gradation of both sand & Gravel.

Shale or rotten stone little Est. gravel/sand ratio 40/60
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.
Est. % of stone over 6" 5-8 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Part of Delta Description Fairly small deposit, probably variable.

Est. Quantity limited cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Deposit very nearly exhausted so further exploration not believed necessary

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/116

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	x 6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 104 U. S. ~~xxxCanada~~ 6-1

Location of Deposit 2 miles south of Bombay

Name of Owner ____________________

Transportation Facilities ____________________

Existing Exposure: Description of Pit ____________________

Mat'l removed ________ cu. yds. Working face ________ feet

Equipment in pit ____________________

Projects furnished ____________________

Description of mat'l ____________________

Shale or rotten stone ________ Est. gravel/sand ratio ________

Gradation of SAND ________ Gradation of GRAVEL ________

Est. % of silt of mat'l passing 1/4" ________ % dry wt.

Est. % of stone over 6" ________ % vol. ________

Sampling: ____________________

________ (See attached sheet for test results)

Nature of Deposit: Type ________ Description ____________________

Est. Quantity ________ cu. yds. Est. Max. Working face ________ feet

Inspector's Recommendations: ____________________

Date ________ Signed ________

File No. S-A-2/117

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2 x	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 105 U. S. ~~xxxQuadx~~ 2-8,9

Location of Deposit 2 miles west of Bombay

Name of Owner Town of Bombay - E. Potter owns extension

Transportation Facilities Railroad 14 miles from Massena - Railroad ½ mile from pit

Existing Exposure: Description of Pit Very large pit apparently resting on till floor. Considerable material over 6" scattered on floor of pit

Mat'l removed 10,000 cu. yds. Working face 9 feet
Equipment in pit Crusher, Elev. loader
Projects furnished All local roads & town uses.
Description of mat'l Material fairly silty and very platey. Considerable material over 6". Numerous boulders & stone up to 8'

Shale or rotten stone Considerable Est.gravel/sand ratio 80/20
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8-12 % dry wt.
Est. % of stone over 6" 30% % vol.
15% over 1'

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Long, poorly developed deposit. No grading of material.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Material apparently too silty and the gravel ratio is too high. Considerable boulders 6' and 10'. No further exploration advised.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/118

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4 x	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 106 U. S. xxxxxxxxx 4-3

Location of Deposit 2½ miles southeast of Helena-1¼ miles northeast of Brasher Iron Works

Name of Owner

Transportation Facilities ½ mile from railroad into Massena
Existing Exposure: Description of Pit Very shallow-silty, resting on till floor. Numerous boulders on floor of pit.

Mat'l removed 8,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished local roads
Description of mat'l Very silty, numerous flat boulders and slabs. Numerous large 3' boulders.

Shale or rotten stone Some Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 8-12 % dry wt.
Est. % of stone over 6" 15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Small localized deposit, very shallow resting on till.

Est. Quantity limited cu. yds. Est. Max. Working face 6 feet

Inspector's Recommendations: Considerable amount of large flat boulders and material is very dirty. No further investigations necessary. Deposit very superficial.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/119

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 107 U. S. ~~or Canada~~ 3-5

Location of Deposit 1½ miles northeast of Bombay

Name of Owner

Transportation Facilities ½ mile from railroad into Massena

Existing Exposure: Description of Pit
No pit open - similar to 105

Mat'l removed - cu. yds. Working face - feet
Equipment in pit -
Projects furnished -
Description of mat'l -

Shale or rotten stone - Est.gravel/sand ratio -
Gradation of SAND - Gradation of GRAVEL -
Est. % of silt of mat'l passing 1/4" - % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly long, well developed beach.

Est. Quantity cu. yds. Est. Max. Working face 10? feet

Inspector's Recommendations: This deposit quite extensive 10-12 pits necessary to prove deposit. If material is necessary in this locality this deposit should be considered.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/120

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1 x	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Moira Quadrangle

Quadrangle Moira Pit 108 U. S. ~~[illegible]~~ 1-9

Location of Deposit 3/4 mile south of Grand Trunk Railroad, 2 miles east of Helena

Name of Owner ______

Transportation Facilities 3/4 mile from railroad into Massena

Existing Exposure: Description of Pit ______
No pits

Mat'l removed - cu. yds. Working face - feet
Equipment in pit ______
Projects furnished ______
Description of mat'l ______

Shale or rotten stone ______ Est. gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing 1/4" - % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly limited probably shallow - similar to 106.

Est. Quantity limited cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: No exploration advised if other deposits prove satisfactory. 10 pits necessary if exploration is necessary.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/121

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Island Quadrangle

Quadrangle Cornwall Isl. Pit 109 ~~U.S.~~ Canada

Location of Deposit ¼ mile north of Canadian custom house on Roosevelt Bridge Highway

Name of Owner

Transportation Facilities Railroad running 100 yds. from pit.
Existing Exposure: Description of Pit Fairly small, bouldery, poorly worked pit. Considerable boulders in floor of pit.

Mat'l removed 1,5000 cu. yds. Working face 9 feet
Equipment in pit None
Projects furnished Roads on the island
Description of mat'l Material silty and very bouldery-Appears like a washed till. Few shells.

Shale or rotten stone some Est.gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8-12 % dry wt.
Est. % of stone over 6" 10-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Small poorly developed beach. Depth of deposit questionable.

Est. Quantity limited cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Because of the high silt content and numerous boulders further exploration on this deposit is not believed necessary.

Date 8/27/41 Signed M. J. Verville

File No. S-A-2/122

D.O. Form No. 56

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 300 xxxxxxxx Canada 166-59

Location of Deposit 1 mile northwest of Spencerville on C.P.R.R.

Name of Owner Mrs. C. M. Black

Transportation Facilities C.P.R.R. crosses through pit.
Existing Exposure: Description of Pit Large pit, deep. Considerable material over 6" left on floor of pit. Pit poorly worked.

Mat'l removed 15,000 cu. yds. Working face 25 feet
Equipment in pit None
Projects furnished Alleged Prasco H Elevator
Description of mat'l Sand has fair gradation, gravel poor with considerable rotten stone. The gravel is very high with considerable material over 6".
Shale or rotten stone 10 Est.gravel/sand ratio 60/40
Gradation of SAND fair Gradation of GRAVEL Poor
Est. % of silt of mat'l passing ¼" 5 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: 1 cu. ft. box taken from face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large, well developed deposit. Considerable material available.

Est. Quantity 250,000 cu. yds. Est. Max. Working face 25 feet

Inspector's Recommendations: This deposit is suitable source of material for work in vicinity of Iroquois Dam Site.

Date 7/10/41 Signed M. J. Verville

File No. S-A-2/123

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 307 ~~xxxxxxxx~~ Canada 166-56

Location of Deposit 3 miles southeast of Merrickville

Name of Owner Dan Kyle

Transportation Facilities 4 miles from C.P.R.R.

Existing Exposure: Description of Pit Small poorly developed pit. Till exposed on floor and rock very close. Considerable water trouble in operating

Mat'l removed 5,000 cu. yds. Working face 12 feet

Equipment in pit None

Projects furnished Local road fill

Description of mat'l Material very dirty very close to/till

Shale or rotten stone some Est.gravel/sand ratio 35/65

Gradation of SAND poor Gradation of GRAVEL fair

Est. % of silt of mat'l passing $\frac{1}{4}$" 15-20 % dry wt.

Est. % of stone over 6" 1-3 % vol.

Sampling: 1 rep. from bottom of pit

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Poorly developed deposit. Very shallow.

Est. Quantity 100,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Because of gradation and silt content, further exploration not believed necessary.

Date 7/11/41 Signed M. J. Verville

File No. S-A-2/124

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 400-401 ~~xxxxxxx~~ Canada 169-59

Location of Deposit 2½ miles east of Kemptville

Name of Owner

Transportation Facilities 1½ miles from Canadian Pacific Railroad
Existing Exposure: Description of Pit Fairly small, clean pit in large deposit. Pit apparently on water table.

Mat'l removed 12,000 cu. yds. Working face 9-15 feet
Equipment in pit None
Projects furnished All local roads & farm uses.
Description of mat'l Material clean with a fair graded gravel and well graded sand. Stratified. Trace of shells.

Shale or rotten stone Trace Est.gravel/sand ratio 40/60
Gradation of SAND Good Gradation of GRAVEL Fair
Est. % of silt of mat'l passing ¼" 1-3 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 rep. sample from face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Very extensive bar with several pits throughout its length. Material very variable.

Est. Quantity 60,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: Favorable source for any sand and gravel used in vicinity of Iroquois. 10-15 test pits necessary for more accurate estimate of extent.

Date 7/10/41 Signed M. U. Verville

File No. S-A-2/125

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 403 U. S. or Canada 171-59

Location of Deposit 2 miles southeast of Osgood Station

Name of Owner I. N. Nixon

Transportation Facilities 8 miles to Canadian Pacific Railroad
Existing Exposure: Description of Pit Small pit, hand worked. Considerable material left in pit because of iron oxide cemented gravel. All the gravel partly cemented.

Mat'l removed 12,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Local roads & contractor's use.
Description of mat'l Material fairly clean, abundance of coarse sand well graded gravel. All material partly cemented with iron oxide.

Shale or rotten stone little Est.gravel/sand ratio 40/60
Gradation of SAND fair Gradation of GRAVEL Good
Est. % of silt of mat'l passing ¼" 1-3 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: 1 rep. sample from face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, well developed deposit. Depth of deposit doubtful.

Est. Quantity 50,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Because of iron oxide, use as filters is doubtful. Material apparently suitable for fill material. Further exploration not believed necessary. More suitable material closer to proposed project.

Date 7/10/41 Signed M. J. Verville

File No. S-A-2/126

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter ~~and~~ Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 405,406, 407 ~~xxxxxx~~ or Canada 173-55

Location of Deposit 5 miles northwest of Richmond

Name of Owner

Transportation Facilities 4 miles from Canadian National Railroad
Existing Exposure: Description of Pit Several small pits in this deposit. All pits very shallow with little material removed.

Mat'l removed 25,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished All local roads & farm use.
Description of mat'l Material has fair gradation, and is fairly clean. Very little material over 6"

Shale or rotten stone little Est.gravel/sand ratio 25/75
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 1-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: Several rep. samples from face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very extensive deposit varying in depth of from a few feet to 10'

Est. Quantity 4,000,000? cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Because of extent of this deposit, approximately 10-20 test pits necessary to estimate extent more exactly. Favorable source for any sand and gravel use.

Date 7/8/41 Signed M. J. Verville

File No. S-A-2/127

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 409 xxxxxxxx or Canada 169-59

Location of Deposit 3 miles east of Kemptville On Canadian Pacific Railroad

Name of Owner C.P.R.R.

Transportation Facilities ______
Existing Exposure: Description of Pit ______
Pit and deposit exhausted

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit ______
Projects furnished ______
Description of mat'l ______

Shale or rotten stone ______ Est. gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing $\frac{1}{4}$" ______ % dry wt.
Est. % of stone over 6" ______ % vol.

Sampling: ______
(See attached sheet for test results)

Nature of Deposit: Type ______ Description ______

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: ______

Date 7/11/41 Signed M. J. Verville

File No. S-A-2/128

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 200 ~~U. S. or~~ Canada 6-6

Location of Deposit $3\frac{1}{2}$ miles northwest of Avonmore, 17 miles north of Moulinette

Name of Owner E. L. Blair

Transportation Facilities 3 miles north of Canadian Pacific R.R.
Existing Exposure: Description of Pit Very large, deep, well worked pit. Now operating-Considerable material over 6" on floor of pit. Till showing on bottom of pit.

Mat'l removed 35,000 cu. yds. Working face 20 feet
Equipment in pit Small dry screening plant
Projects furnished Local roads
Description of mat'l Material has fair gradation with considerable material over 6" and quite silty; numerous shells.

Shale or rotten stone little Est.gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing $\frac{1}{4}$" 8-12 % dry wt.
Est. % of stone over 6" 15-25 % vol.

Sampling: 1 rep. bag sample from working face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very long, well developed beach, includes approximately 5 farms. Material slightly stratified.

Est. Quantity 500,000 cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: Favorable source for any sand & gravel filter or fill uses. 12 test pits necessary for more accurate estimate of extent.

Date 7/1/41 Signed M. J. Verville

File No. S-A-2/129

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 202 ~~xxxxxxxx~~ Canada 12-4

Location of Deposit 2 miles south of Finch, Stormont Co., 10 miles to Highway #2

Name of Owner Sylvia Lachapello, Finch

Transportation Facilities 10 mile truck haul to Highway 2, 2½ miles to C.P.R.R.
Existing Exposure: Description of Pit 3 large pits and 4th being opened. Now operating 1 pit only, sand no gravel- 1 is well graded sand & gravel. Further expansion possible in all pits.

Mat'l removed 40,000 cu. yds. Working face 5-20 feet
Equipment in pit 1 crusher & small dry screening plant
Projects furnished Highway #2 & Cornwall Locks
Description of mat'l Material very variable-1 pit comprised of only snad (stratified) the other pit showing a combined sand & gravel. Few shells

Shale or rotten stone little Est.gravel/sand ratio 30/60
Gradation of SAND Poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 3-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 rep. sand and 1 rep. sand & gravel

(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description Large, well-developed stratified deposit. Material graded throughout deposit.

Est. Quantity 200,000 ? cu. yds. Est. Max. Working face 5-20 feet

Inspector's Recommendations: Several test pits necessary for more accurate estimate of extent. This deposit should prove satisfactory source of filter and fill material. Further exploration advised.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/130

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 206 ~~U. S.~~ Canada

Location of Deposit 8 miles east of Winchester Springs

Name of Owner

Transportation Facilities 8 mile truck haul on dirt road to surfaced country road

Existing Exposure: Description of Pit Small pit, used for local uses-
Considerable cleaning of pit necessary

Mat'l removed 5,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished All local farm and road uses.
Description of mat'l Material fairly clean, and fairly well graded.
Few shells-gravel platey.

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Low, poorly developed feature. Extent doubtful.

Est. Quantity 5,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Considerable exploration necessary.
Material apparently suitable for any use-Extent doubtful.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/131

D.O. Form No. 85

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 207 Canada

Location of Deposit 4 miles east of Winchester

Name of Owner

Transportation Facilities 4 mile truck haul to surfaced county road

Existing Exposure: Description of Pit Very small pit open. Pit slumped so exposure is very poor. Few boulders scattered over bottom of pit.

Mat'l removed 1,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Local concrete use
Description of mat'l Material fairly clean with fair gradation of both sand and gravel - Few shells - Few boulders

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 5-8 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, low deposit

Est. Quantity 8,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Several test pits necessary for more accurate estimate on extent. Water table near surface in vicinity of pit, may have difficulty working pit.

Date 7/3/41 Signed M. J. Verville

File No. S A-2/132

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 208 ~~U. S.~~ or Canada

Location of Deposit $3\frac{1}{2}$ miles northeast of Williamsburg

Name of Owner

Transportation Facilities $11\frac{1}{2}$ mile truck haul to Morrisburg

Existing Exposure: Description of Pit Small poorly worked pit mostly very superficial - stripping operation.

Mat'l removed 5,000 cu. yds. Working face 6.0 feet

Equipment in pit None

Projects furnished Local dirt roads

Description of mat'l Material silty and contains numerous cobbles Few shells- Few large 3' boulders.

Shale or rotten stone little Est. gravel/sand ratio 60/40

Gradation of SAND Fair Gradation of GRAVEL Good

Est. % of silt of mat'l passing 1/4" 8-10 % dry wt.

Est. % of stone over 6" 5-8 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Apparently superficial deposit - limits doubtful.

Est. Quantity 8 to 10,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Considerable exploration necessary to locate limits of deposit. Use as filter material doubtful.

Date 7/3/41 Signed M. Verville

File No. S-A-2/133

B.O. Form No. [illegible]

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 209 Canada

Location of Deposit 2 miles west of Winchester

Name of Owner

Transportation Facilities $\frac{1}{4}$ mile south of Canadian Pacific Railroad

Existing Exposure: Description of Pit Large pit, shallow, till exposed on floor of pit

Mat'l removed 8,000 cu. yds. Working face 10 feet
Equipment in pit Crusher and loading platform
Projects furnished Local road fill and surfacing
Description of mat'l Well graded sand and gravel, considerable shale and numerous shells

Shale or rotten stone Considerable Est.gravel/sand ratio 55-45
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 8 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach & Bar Description Deposit is of 2 types. The gravel being in the beach and the bar being chiefly sand.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 10 feet

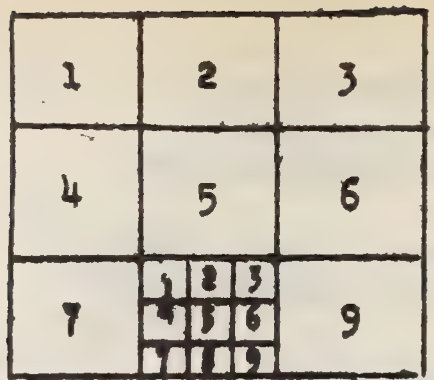
Inspector's Recommendations: Considerable exploration necessary to find contact between uniform fine sand bar and the fairly good gravel in the beach.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/134

D.O. Form No. 55

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT



Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 8 Uxxxxxx Canada 170-67

Location of Deposit 3 miles norhtwest of Moulinette

Name of Owner G. T. Coleman

Transportation Facilities $3\frac{1}{2}$ mile truck haul to Moulinette

Existing Exposure: Description of Pit Large pit,considerable material over 6" and numerous large boulders 10' in pit. Pit now operating. Till now exposed on floor and one end of pit.

Mat'l removed 6,000 cu. yds. Working face 20 feet
Equipment in pit 1 small Bay City shovel.
Projects furnished Local roads
Description of mat'l Material fairly clean with a poor sand gradation but good gravel. Numerous shells. Considerable fine sand.

Shale or rotten stone little Est.gravel/sand ratio 40/60
Gradation of SAND Poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 5 % dry wt.
Est. % of stone over 6" 5-10 % vol.

Sampling: 1 small rep. bag from face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large deposit, Extent questionable. Till may be very close.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: Favorable source of fill material. 5-6 pits necessary to limit deposit. 6,000 cu. yds. estimate is minimum estimate. Test pits may prove that more material is available.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/135

D.O. Form No. [illegible]

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 9 ~~U. S.~~ Canada 170-67

Location of Deposit $3\frac{1}{4}$ miles north of Moulinette

Name of Owner Black River Pit

Transportation Facilities 1 mile from New York Central Railroad
Existing Exposure: Description of Pit Fairly small pit, nearly exhausted.

Mat'l removed 8,000 cu. yds. Working face 15' feet
Equipment in pit None
Projects furnished local roads
Description of mat'l Material poorly graded, with considerable material over 6" and considerable silt.

Shale or rotten stone little Est. gravel/sand ratio 40/60
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 10 % dry wt.
Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly small beach, poorly developed and poorly graded.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Because of silt and boulder content and limited extent of deposit, further exploration is not believed necessary.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/136

D.O. Form No. 55

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 10 ~~XXXXXX~~ Canada 170-67

Location of Deposit 5½ miles north of Moulinette

Name of Owner Harrison Corner Pit

Transportation Facilities Truck haul for 5½ miles to Moulinette

Existing Exposure: Description of Pit Small pit with numerous boulders on floor. Till exposed on floor of pit and is very close to face. Pit nearly exhausted.

Mat'l removed 10,000 cu. yds. Working face 6-12 feet
Equipment in pit Elevating grader
Projects furnished Local roads & clu culverts
Description of mat'l Material very heavy in gravel. Considerable material over 6". Sand shows poor gradation. Few shells.

Shale or rotten stone little Est.gravel/sand ratio 50/50
Gradation of SAND Poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 5 % dry wt.
Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Small poorly developed beach, apparently very shallow, resting on exposed till ridge.

Est. Quantity 8 to 10,000 cu. yds. Est. Max. Working face 6-12 feet

Inspector's Recommendations: Because of gradation and quantity of silt and material over 6" as well as limited extent further exploration is not believed necessary.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/137

D.O. Form No. 48

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 12 U. S. or Canada 170-67

Location of Deposit ½ mile southeast of Northfield Station

Name of Owner Ottawa Railroad

Transportation Facilities New York Central runs through pit-13 miles by rail to Cornwall

Existing Exposures Description of Pit Very large well worked pit. Old railroad spur into pit. Pit very clean. Apparently excavated to till floor.

Mat'l removed 120,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Ballast for railroad
Description of mat'l Material fairly clean with fair gradation of sand and gravel. Considerable fine to medium material. Few shells

Shale or rotten stone little Est. gravel/sand ratio 70/30
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing 1/4" 3-5 % dry wt.
Est. % of stone over 6" 3-5 % vol.

Sampling: 1 rep. bag from old face.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large, well-developed beach, stratified.

Est. Quantity 150,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: 12 test pits necessary for extent of deposit. Very favorable source of material for any work in vicinity of Cornwall. Further exploration advised.

Date 7/3/41 Signed M. J. Verville

File No. S-A-2/T32
ld
D.O. Form No. [illegible]

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangle
Cornwall Quadrangle

Quadrangle Cornwall Pit 15 Canada 171-68

Location of Deposit 1¼ miles northwest of Bonville, Ont.-9 miles north of Cornwall

Name of Owner 9 mile truck haul to Cornwall

Transportation Facilities 9 mile truck haul to Cornwall.

Existing Exposure: Description of Pit Pit small-apparently shallow. Considerable trouble with water. Pit nearly exhausted.

Mat'l removed 50,000 cu. yds. Working face 20 feet

Equipment in pit Screening plant, bulldozer & scraper

Projects furnished All local roads

Description of mat'l Material has fair gradation of sand & gravel, but has considerable silt, and numerous shells.

Shale or rotten stone little Est. gravel/sand ratio 50/50

Gradation of SAND Gradation of GRAVEL

Est. % of silt of mat'l passing 1/4" 10-15 % dry wt.

Est. % of stone over 6" 5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large, well-developed beach. Till floor close to surface.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 9 feet

Inspector's Recommendations: Because of limited extent and hauling distance from projects, no further exploration is believed necessary.

Date 7/1/41 Signed M. J. Verville

File No. S-A-2/139

D.O. Form No. 45

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 16 U. S. or Canada 173-67

Location of Deposit 2 miles northwest of Manckland Station-16 miles north of Cornwall

Name of Owner J. A. Stewart, R.F.D.#2, Maxville

Transportation Facilities 2 miles north of C.P.R.R. 16 miles north of Cornwall
Existing Exposure: Description of Pit Shallow, small pit. Considerable water trouble in operating. Approximately 2' of stripping.

Mat'l removed 16,000 cu. yds. Working face 5 feet
Equipment in pit None
Projects furnished Ballast for C.P.R.R. and concrete in Cornwall.
Description of mat'l Material has fair gradation and is fairly clean with little rotten stone. Deposit variable and stratified. Apparently too much fine to med. material.
Shale or rotten stone little Est.gravel/sand ratio 35/65
Gradation of SAND poor Gradation of GRAVEL fair
Est. % of silt of mat'l passing $\frac{1}{4}$" 5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None
(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly small shallow beach very variable in nature.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 5 feet

Inspector's Recommendations: Because of gradation and limited extent, no further exploration.

Date 7/1/41 Signed M. J. Verville

File No. S-A-2/140

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Huntingdon Quadrangle

Quadrangle Huntingdon Pit 800 ~~County~~ Canada 3-1

Location of Deposit South of Grand Trunk Railroad at Baudet River, P.Q.

Name of Owner Grand Trunk Railroad

Transportation Facilities Railroad to Cornwall goes through pit.

Existing Exposure: Description of Pit Very large pit, now overgrown with grass and trees. Pit nearly exhausted.

Mat'l removed 120,000 cu. yds. Working face 12-15 feet
Equipment in pit None
Projects furnished Ballast for Grand Trunk Railroad
Description of mat'l Material fairly dirty, and poorly graded. Sand and gravel. Considerable rotten stone.

Shale or rotten stone 5% Est. gravel/sand ratio 40/60 or higher
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing 1/4" 10 % dry wt.
Est. % of stone over 6" 5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Fluvio-glacial Description long well developed esker. Cont. of pit #2

Est. Quantity 30,000 cu. yds. Est. Max. Working face 12-15 feet

Inspector's Recommendations: Scalping operations would be necessary. Better material available closer to project.

Date 7/1/41 Signed M. J. Verville

File No. S-A-2/141

D.O. Form No. [illegible]

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Huntingdon Quadrangle

Quadrangle Huntingdon Pit 801 Canada 3-4

Location of Deposit Baudet, P.Q., 100 yds. south of Highway #2

Name of Owner A. Houle, Baudet, P.Q.

Transportation Facilities 25 mile water haul-$\frac{1}{4}$ mile south of Grand Trunk Railroad

Existing Exposure: Description of Pit Large, deep, well worked, now operating. Considerable material over 6" left in pit.

Mat'l removed 300,000 cu. yds. Working face 10-30 feet
Equipment in pit Elevating Grader
Projects furnished All local roads-Highway #2 & ballast for railroad
Description of mat'l Material very variable and stratified ranging from silt lenses to coarse gravel & boulders. Material fairly clean.

Shale or rotten stone Approx. 5% Est. gravel/sand ratio 50/50
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing 1/4" 7 % dry wt.
Est. % of stone over 6" 8-10 % vol.

Sampling: 1 rep. sand from face of pit.

(See attached sheet for test results)

Nature of Deposit: Type Fluvio-glacial Description Long well developed esker and is stratified.

Est. Quantity 30,000 cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: Apparently too much rotten stone and material over 6" for use as filters. Material suitable for fill material. 10 pits necessary to approx. quantity.

Date 7/1/41 Signed M. J. Verville

File No. S-A-2/142

N.G. Form No. 88

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Ottawa Quadrangle

Quadrangle OTTAWA Pit 500 ~~xxxxxxx~~ Canada

Location of Deposit 6 miles southwest of Ottawa on Richmond Road

Name of Owner R. R. Foster & Sons, Ltd., Ottawa, Ont.-Britannia Heights

½ mile from Canadian National Railroad
Transportation Facilities Approximately 44 mile truck haul to Morrisburg.
Existing Exposure: Description of Pit Very deep, large pit with a second pit across highway. Pit now being worked. Material stratified-Expansion of pit limited by residential section & highways.

Mat'l removed 150,000 cu. yds. Working face 25-40 feet
Equipment in pit 2 elev. graders, 1 shovel
Projects furnished Most roads, fill & surfaces-concrete in vicinity of Ottaw
Description of mat'l Material very variable, apparently fair gradation. Gravel is fine to med. Very little coarse

Shale or rotten stone little Est.gravel/sand ratio 25/75
Gradation of SAND fair(fine Gradation of GRAVEL Good to 3"
Est. % of silt of mat'l passing ¼" 1-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 rep. from face of pit.

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Large,deep, well developed beach, stratified.

Est. Quantity 250,000 cu. yds. Est. Max. Working face 20-40 feet

Inspector's Recommendations: Because of limitations of deposit by residential section & highways further exploration is not advised.

Date 7/8/41 Signed M. J. Verville

File No. S-A-2/143

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
OTTAWA Quadrangle

Quadrangle OTTAWA Pit 5055 ~~xxxxxxxx~~ Canada

Location of Deposit 4 miles south of Ottawa on Highway #21 to Morrisburgh

Name of Owner G.H. Spratt, Billings Bridge, P.Q.

Transportation Facilities 1-3/4 miles to C.P.R.R.
Existing Exposure: Description of Pit Very large well worked deposit. Clay exposed on floor of pit & few thin lenses in face of pit. Abundance rotten stone.

Mat'l removed 300,000 cu. yds. Working face 25 feet
Equipment in pit Elevating grader
Projects furnished Local roads & contract use around OTTAWA
Description of mat'l Sand is poorly graded in that too much fine, gravel has poor gradation. Abundance rotten stone & shale Few shells
Shale or rotten stone Approx. 15% Est.gravel/sand ratio 50/50
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing $\frac{1}{4}$" 5-10 % dry wt.
Est. % of stone over 6" 1-5 % vol.

Sampling: 1 rep. bag from stock pile

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very extensive deep deposit.

Est. Quantity 4,000,000 cu. yds. Est. Max. Working face 25 feet

Inspector's Recommendations: Because of nature of material in gradation, and amount of rotten stone, further exploration is not believed necessary.

Date 7/8/41 Signed M. J. Verville

File No. S-A-2/144

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Arnprior Quadrangle

Quadrangle Arnprior Pit 600 xxxxxxxx Canada

Location of Deposit 1½ miles east of town of Arnprior

Name of Owner

Transportation Facilities ½ mile from Canadian National Railroad
Existing Exposure: Description of Pit Fairly large, well worked, clean pit. Now operating. Chiefly sand taken out. Apparently on water table in bottom of pit.

Mat'l removed 20,000 cu. yds. Working face 20 feet
Equipment in pit Small dry screening plant
Projects furnished Local black top roads and highway ice sanding
Description of mat'l Material contains very little gravel and is cleanly stratified. Few thin lenses of silt & clay.

Shale or rotten stone - Est.gravel/sand ratio 10/90
Gradation of SAND Good Gradation of GRAVEL Good to 1"
Est. % of silt of mat'l passing ¼" 10-15 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 rep. bag sample

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Limited deposit, probably restng on rock as there is a quarry very close.

Est. Quantity 150,000 ?cu. yds. Est. Max. Working face 20 feet

Inspector's Recommendations: If select sand is required this is a favorable source. Lack of gravel makes the deposit of no value for fill material. Further exploration not believed necessary.

Date 7/8/41 Signed M. J. Verville

File No. S-A-2/145

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Russell Quadrangle

Quadrangle Russell Pit 900 ~~U. S.~~ or Canada

Location of Deposit 3 miles northwest of town of Leonard

Name of Owner

Transportation Facilities 2 miles from Canadian Pacific Railroad
Existing Exposure: Description of Pit Small pit apparently on till floor. Expansion of pit favorable.

Mat'l removed 10,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished All local roads
Description of mat'l Material has a good sand gradation and is stratified with a fair gravel gradation.

Shale or rotten stone - Est.gravel/sand ratio 40/60
Gradation of SAND Good Gradation of GRAVEL fair
Est. % of silt of mat'l passing $\frac{1}{4}$" 3-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: 1 rep. bag from face of pit
(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Long well developed, stratified deposit. Probable maximum depth of till 10'.

Est. Quantity 500,000 ? cu. yds. Est. Max. Working face 6-10 feet

Inspector's Recommendations: Character of till floor of pit may decrease above estimate. 12 test pits necessary for more accurate estimate. Further exploration advised.

Date 7/8/41 Signed M. J. Verville

File No. S-A-2/146

D.O. Form No.86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

x 1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Massena Quadrangle

Quadrangle Massena Pit 32 U. S. ~~xxCanada~~ 1-3

Location of Deposit 200 yds. east of mouth of Massena Power Canal

Name of Owner American Aluminum Co.(?)

Transportation Facilities Located on River Road

Existing Exposure: Description of Pit Fairly large pit, not now being used. Underlying glacial till floor showing through sand and gravel in many places.

Mat'l removed 10,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Used in building Massena Weir
Description of mat'l Material quite silty and contains considerable material over 6".

Shale or rotten stone some Est.gravel/sand ratio 60/40
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 5-10 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well formed marine beach grading into a boulder bar on the eastern end of deposit. Deposit not very deep.

Est. Quantity 3,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Material from this deposit is suitable for any work done in the vicinity of the deposit, but more satisfactory deposits are located near the project for any large quantity of material.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/147

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 301 ~~Xxxxxxx~~ Canada 166-60

Location of Deposit $1\frac{1}{2}$ miles southeast of Spencerville, Ont.

Name of Owner

Transportation Facilities Located on black top road-6 miles from Prescott, Ont.
Existing Exposure: Description of Pit Fairly small shallow pit.

Mat'l removed 5,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Material contains considerable silt and platey gravel. Considerable rotten stone.

Shale or rotten stone Considerable Est.gravel/sand ratio 60/40
Gradation of SAND fair Gradation of GRAVEL poor
Est. % of silt of mat'l passing $\frac{1}{4}$" 10-15 % dry wt.
Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly small deposit with outcrop exposed at east end of pit.

Est. Quantity 5,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Material suitable for backing or roads. Not clean enough for filters unless processed.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/148

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 302 U. S. or Canada 168-59

Location of Deposit 2½ miles east of Oxford Station, Ontario

Name of Owner

Transportation Facilities Located on blacktop road to Spencerville
Existing Exposure: Description of Pit Small pit consisting of 2 parts- a sandy and a sand and gravel phase.

Mat'l removed 5,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished Local roads as fill and surface
Description of mat'l Material of 2 types -afairly uniform fine to med. SAND & a SAND & Gravel.

Shale or rotten stone little Est.gravel/sand ratio 40/60
Gradation of SAND fair Gradation of GRAVEL poor
Est. % of silt of mat'l passing ¼" 5-10 % dry wt,
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Low well developed beach, stratified.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Sufficient quantity of suitably well graded material is not believed to be present in this deposit.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/149

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 303 U. S. or Canada 165-59

Location of Deposit Located in town of Roebuck, Ontario, 9 miles northwest of Prescott

Name of Owner

Transportation Facilities Located on black top road

Existing Exposure: Description of Pit Large pit now being worked by the town. Expansion of pit doubious because of settlement.

Mat'l removed 10,000 cu. yds. Working face 15 feet

Equipment in pit None

Projects furnished -

Description of mat'l Material fairly well graded, but gravel is platey.

Shale or rotten stone some Est.gravel/sand ratio 50/50

Gradation of SAND fair Gradation of GRAVEL fair

Est. % of silt of mat'l passing ¼" 5- 10 % dry wt.

Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed beach, slightly stratified. Bedrock exposed in considerable area adjacent to pit.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: Suitable source for any sand and gravel material necessary for the project except concrete.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/150

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 304 ~~U. S.~~ Canada 166-58

Location of Deposit 3 miles north of town of Roebuck Ont.

Name of Owner

Transportation Facilities Located on 2nd class dirt road
Existing Exposure: Description of Pit Small pit which the material is poorly graded.

Mat'l removed 5,000 cu. yds. Working face 8 feet
Equipment in pit None
Projects furnished
Description of mat'l Poorly graded sand, little gravel.

Shale or rotten stone trace Est.gravel/sand ratio 20/80
Gradation of SAND poor Gradation of GRAVEL poor
Est. % of silt of mat'l passing ¼" 3-5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit; Type Beach with dune cap Description Poorly developed beach with a cap of uniform dune SAND

Est. Quantity 8,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Pit very small and poorly graded for most construction uses. Deepening of pit limited because of local high water table.

Date 2/8/42

Signed M. J. Verville

File No. S-A-2/151

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 305 ~~XxxSxxxx~~ Canada 164-57

Location of Deposit 1 mile east town of North Augusta, Ont.

Name of Owner

Transportation Facilities

Existing Exposure: Description of Pit No pit, but gravel exposed in road cut.

Mat'l removed - cu. yds. Working face - feet

Equipment in pit -

Projects furnished -

Description of mat'l Material fairly well graded in road cut.

Shale or rotten stone trace Est. gravel/sand ratio 30/60

Gradation of SAND fair Gradation of GRAVEL fair

Est. % of silt of mat'l passing ¼" - % dry wt.

Est. % of stone over 6" - % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Poorly developed feature with considerable blow sand as cap.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 8 feet

Inspector's Recommendations: Very small deposit and not sufficiently well graded for filter use. However, it may be suitable for road material.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/152

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 306 ~~xxxxxx~~ Canada 165-57

Location of Deposit 4 miles north of North Agusta

Name of Owner

Transportation Facilities Poor road conditions
Existing Exposure: Description of Pit Fairly large deposit with bedrock floor covering entire pit.

Mat'l removed 10,000 cu. yds. Working face 8 feet
Equipment in pit None
Projects furnished All local roads
Description of mat'l Material fairly well graded but contains considerable clay and silt. Gravel is quite platey.

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 10-15 % dry wt.
Est. % of stone over 6" 3-5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly large beach resting on bedrock.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 8 feet

Inspector's Recommendations: Material suitable for road or fill material only. Contains too much silt for filter use. Expansion of pit doubtful, because of outcrops of bedrock.

Date 2/8/42

Signed M. J. Verville

File No. S-A-2/153

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Merrickville Quadrangle

Quadrangle Merrickville Pit 308 ~~XXXXXXXX~~ Canada 167-58

Location of Deposit ½ mile northwest of town of East Oxford, Ont.

Name of Owner

Transportation Facilities Located on black top road
Existing Exposure: Description of Pit Very small pit located in generally sand. Gravel sizes lacking.

Mat'l removed 8,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished -
Description of mat'l Material consists of fine to coarse SAND, but very little gravel.

Shale or rotten stone trace Est.gravel/sand ratio 20/80
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" 5-8 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description Poorly developed structure with very little coarse material.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: Material suitable for any use or project. Because of poor road conditions in vicinity of deposit working conditions of pit may be poor.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/154

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 402 Canada 170-59

Location of Deposit Located just north of town of Reid Mills

Name of Owner

Transportation Facilities Located on 2nd class dirt road
Existing Exposure: Description of Pit Small pit now being operated for road material. Expansion of pit possible.

Mat'l removed 10,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished All local roads
Description of mat'l Material well graded and apparently sound.

Shale or rotten stone little Est. gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 3-5 % dry wt.
Est. % of stone over 6" 8-10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed long deposit, may grade into boulder bar on north end of deposit.

Est. Quantity 20,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: Favorable source for sand and gravel for any proposed use.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/155

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 404 ~~U. S. or~~ Canada 172-57

Location of Deposit 2 miles southeast of Manotick, Ont.

Name of Owner

Transportation Facilities Located on black top road

Existing Exposure: Description of Pit Fairly large pit now nearly exhausted. Expansion of pit to north limited by stream.

Mat'l removed 20,000 cu. yds. Working face 15 feet

Equipment in pit None

Projects furnished All local roads and town uses.

Description of mat'l Fairly well graded with considerable sand.

Shale or rotten stone little Est.gravel/sand ratio 30/70

Gradation of SAND Gradation of GRAVEL

Est. % of silt of mat'l passing ¼" 3-5 % dry wt.

Est. % of stone over 6" 3-5 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed feature with considerable blow sand cover.

Est. Quantity limited cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations:

Deposit nearly exhausted

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/156

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 408 XXXSXXXX Canada 171-55

Location of Deposit 7 miles southwest of Richmond, Ontario

Name of Owner ______

Transportation Facilities Located on black top road
Existing Exposure: Description of Pit Small pit composed of a slightly washed glacial till.

Mat'l removed 5,000 cu. yds. Working face 8 feet
Equipment in pit None
Projects furnished Road fill
Description of mat'l Slightly washed glacial till with considerable silt and coarse material over 6.0".

Shale or rotten stone little Est.gravel/sand ratio 50/50
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 10-15 % dry wt.
Est. % of stone over 6" 15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Poorly developed feature - being only a slightly washed glacial till ridge.

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations:
Material suitable only for road fill.

Date 2/8/42 Signed M. J. Verville

File No. S-A-2/157

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 410 ~~U.S.~~ Canada 170-59

Location of Deposit Located at North Mountain

Name of Owner ______

Transportation Facilities ______
Existing Exposure: Description of Pit ______

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit ______
Projects furnished ______
Description of mat'l ______

Shale or rotten stone ______ Est. gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing ¼" ______ % dry wt.
Est. % of stone over 6" ______ % vol.

Sampling: ______
______ (See attached sheet for test results)

Nature of Deposit: Type ______ Description ______

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: Material only a blow sand and deposit with few pockets of gravel.

Date ______ Signed ______

File No. S-A-2/158

D.O. Form No. 86.

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Kemptville Quadrangle

Quadrangle Kemptville Pit 411-412 ~~U. S. or~~ Canada 169-59

Location of Deposit 6 miles northeast of Kemptivlle, Ont.

Name of Owner

Transportation Facilities Located on black top roads
Existing Exposure: Description of Pit Numerous small pits throughout deposit. Pits range in gradation of from fine sand to sand and gravel.

Mat'l removed - cu. yds. Working face feet
Equipment in pit None
Projects furnished All local roads
Description of mat'l Material ranges in gradation of from uniform SAND to SAND AND GRAVEL.

Shale or rotten stone little Est.gravel/sand ratio variable
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" % dry wt.
Est. % of stone over 6" % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Well developed stratified deposit extending for 2 miles.

Est. Quantity 50,000 cu. yds, Est. Max. Working face 20 feet

Inspector's Recommendations: Favorable source for any sand and gravel uses on the project.

Date 2/ 8/42 Signed M. J. Verville

File No. S-A-2/159

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 1 ~~xxxxxxxx~~ Canada 172-72

Location of Deposit ½ mile west of Glen Gordon Station, Ontario

Name of Owner

Transportation Facilities Near Canadian Pacific Railroad ½ mile from black top road

Existing Exposure: Description of Pit Fairly large pit nearly exhausted. Contains considerable boulders.

Mat'l removed 10,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Local roads & little railroad fill
Description of mat'l Material fairly well graded - contains considerable boulders and silt.

Shale or rotten stone little Est.gravel/sand ratio 35/65
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 8-12 % dry wt.
Est. % of stone over 6" 10 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Fairly well developed feature. Till is believed to be close.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Pit nearly exhausted and more suitable material can be found closer to the project.

Date 2/16/42 Signed M. J. Verville

File No. S-A-2/160

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 2 ~~U. S.~~ Canada 172-71

Location of Deposit 1 mile southeast of St. Raphael West Ont.

Name of Owner

Transportation Facilities 1 mile from black top road, 3 miles from railroad
Existing Exposure: Description of Pit Large pit now operating. Numerous piles of cobbles in pit over 4".

Mat'l removed 12,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished Dirt roads as fill and black top surface
Description of mat'l Material fairly dirty and well graded. Considerable material over 6".

Shale or rotten stone little Est.gravel/sand ratio 35/65
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 10-12 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed feature resting on low till ridge

Est. Quantity 10,000 cu. yds. Est. Max. Working face 15 feet

Inspector's Recommendations: Suitable material for roads and possibly backing material may be obtained from this deposit.

Date 2/16/41 Signed M. T. Verville

File No. S-A-2/161

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 3 ~~XXXX~~ or Canada 173-71

Location of Deposit 1-1/4 mls. North of St. Raphael West, Ont.

Name of Owner

Transportation Facilities 1 ml. from black top road.
Existing Exposure: Description of Pit Fairly large pit now nearly exhausted. Pit only used occasionally.

Mat'l removed 10,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished -
Description of mat'l Mat. dirty and contains platey gravel, and considerable shale.

Shale or rotten stone Some Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing ¼" 10.15 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed feature extending east and west and grading into till on both ends of pit.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Estimated yardage may be too large as the glacial till may rise more rapidly than is evident on the surface. More suitable material can be found closer to the projects.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/162
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit A XXXX. or Canada 172-70

Location of Deposit 3 mls. East of Martintown, Ont.

Name of Owner

Transportation Facilities 3 ml. dirt rd. haul to black top rd.
Existing Exposure: Description of Pit

Mat'l removed ___ cu. yds. Working face ___ feet
Equipment in pit
Projects furnished
Description of mat'l

Shale or rotten stone ___ Est.gravel/sand ratio
Gradation of SAND ___ Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" ___ % dry wt.
Est. % of stone over 6" ___ % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ___ Description

Est. Quantity ___ cu. yds. Est. Max. Working face ___ feet

Inspector's Recommendations: Deposit not visited

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/163
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
/ Cornwall Quadrangle

Quadrangle Cornwall Pit 5 ~~XXXX~~ or Canada 170-69

Location of Deposit 1-1/2 mi. North of Cornwall

Name of Owner

Transportation Facilities 1/4 mi. haul on dirt rd. to black top rd.
Existing Exposure: Description of Pit Very small pits. Mat. very dirty and contains numerous boulders.

Mat'l removed 3,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Local roads as fill.
Description of mat'l Mat. composed of a slightly washed glacial till.

Shale or rotten stone Little Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing ¼" 15 % dry wt.
Est. % of stone over 6" 10-15 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description Poorly developed feature. Mat. only slightly washed.

Est. Quantity 5,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Mat. too dirty and bouldery for any use but road fill.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/164
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 6 XXXX or Canada 169-68

Location of Deposit 1 ml. Northeast of Moulinette

Name of Owner ____

Transportation Facilities 3/4 of a mile road would be necessary.
Existing Exposure: Description of Pit None

Mat'l removed None cu. yds. Working face - feet
Equipment in pit -
Projects furnished -
Description of mat'l -

Shale or rotten stone - Est.gravel/sand ratio -
Gradation of SAND - Gradation of GRAVEL -
Est. % of silt of mat'l passing ¼" - % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description
Well developed feature.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Considerable exploration necessary for more accurate estimate of quantity.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/165

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 7 ~~U.S.~~ or Canada 169-6S

Location of Deposit 1/4 mile Northeast of Moulinette

Name of Owner

Transportation Facilities 1/4 of a mile of road building necessary
Existing Exposure: Description of Pit
None

Mat'l removed None cu. yds. Working face - feet
Equipment in pit -
Projects furnished -
Description of mat'l -

Shale or rotten stone - Est.gravel/sand ratio -
Gradation of SAND - Gradation of GRAVEL -
Est. % of silt of mat'l passing ¼" - % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None
(See attached sheet for test results)

Nature of Deposit: Type Marine beach Description fairly large well developed feature.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Considerable exploration necessary for samples and a more accurate estimate of quantity.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/166

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 11 ~~XXXX~~ or Canada 171-68

Location of Deposit 2 miles Southeast of Northfield, Ont.

Name of Owner

Transportation Facilities Very poor roads for 2 miles into pit.
Existing Exposure: Description of Pit Large pit with crusher. Pit supplying only crushed stone.

Mat'l removed 8,000 cu. yds. Working face 12 feet
Equipment in pit Crusher
Projects furnished Local roads
Description of mat'l Mat. consists chiefly of gravel over 2"

Shale or rotten stone Some Est.gravel/sand ratio 80/20
Gradation of SAND Poor Gradation of GRAVEL Poor
Est. % of silt of mat'l passing ¼" - % dry wt.
Est. % of stone over 6" 20 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Boulder Bar Description Fairly large bar being very uniform in gradation of mat.

Est. Quantity - cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Mat. too coarse for any use.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/167

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 13 ~~XXXX~~. or Canada 170-66

Location of Deposit Dixon, Ont. 1-1/2 mi. North of N. Lunenburg

Name of Owner

Transportation Facilities
Existing Exposure: Description of Pit 2 small pits

Mat'l removed cu. yds. Working face feet
Equipment in pit
Projects furnished
Description of mat'l

Shale or rotten stone Est.gravel/sand ratio
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" % dry wt.
Est. % of stone over 6" % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type Description

Est. Quantity cu. yds. Est. Max. Working face feet

Inspector's Recommendations: Expansion of pit believed to be impossible because of cemetery and farms.

Date 2/16/41

Signed M. J. Verville

File No. S-A-2/168

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 14 ~~U.S.~~ or Canada 169-66

Location of Deposit 1-1/2 mi. west of Lunenburg

Name of Owner

Transportation Facilities
Existing Exposure: Description of Pit Small pit

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit
Projects furnished
Description of mat'l Gravel with very little sand. Material chiefly over 2"

Shale or rotten stone ______ Est.gravel/sand ratio 80/20
Gradation of SAND ______ Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" ______ % dry wt.
Est. % of stone over 6" ______ % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ______ Description

Est. Quantity ______ cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: Too much large gravel - Pit not believed suitable for any use.

Date 2/16/41 Signed M. J. Verville

File No. S-A-2/169

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Cornwall Quadrangle

Quadrangle Cornwall Pit 17 ~~U.S.~~ or Canada 172-70

Location of Deposit 3 miles East of Martintown, Ont.

Name of Owner

Transportation Facilities 3 mi. dirt road haul to black-top road
Existing Exposure: Description of Pit

Mat'l removed ____ cu. yds. Working face ____ feet
Equipment in pit
Projects furnished
Description of mat'l

Shale or rotten stone ____ Est.gravel/sand ratio
Gradation of SAND ____ Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" ____ % dry wt.
Est. % of stone over 6" ____ % vol.

Sampling:

(See attached sheet for test results)

Nature of Deposit: Type ____ Description

Est. Quantity ____ cu. yds. Est. Max. Working face ____ feet

Inspector's Recommendations: Deposit not visited

Date 2/16/41

Signed M. J. Verville

File No. S-A-2/170
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 100 XXXX. or Canada 168-64

Location of Deposit Located at town of Bouckhill, Ont.

Name of Owner

Transportation Facilities 2 mls. from black top rd. to Morrisburg
Existing Exposure: Description of Pit Large shallow pit with glacial till exposed on floor of pit. Few large boulders on floor of pit.

Mat'l removed 15,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished All local roads
Description of mat'l Mat. silty, being a slightly washed glacial till.

Shale or rotten stone Little Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing ¼" 15 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Poorly developed feature with no sharp line between beach and glacial till.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Because of silt and boulder content of material it appears suitable for road fill only.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/171

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 101 XXXX or Canada 168-63

Location of Deposit 3/4 ml. S.E. of Williamsburg, Ont.

Name of Owner

Transportation Facilities 1/2 ml. to black top rd. to Morrisburg.
Existing Exposure: Description of Pit Very small pit with poor material showing in exhisting face.

Mat'l removed 5,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished Local roads and town uses.
Description of mat'l Mat. fairly clean, but contains considerable shale and platey gravel.

Shale or rotten stone Some Est.gravel/sand ratio 35/65
Gradation of SAND Fair Gradation of GRAVEL Fair
Est. % of silt of mat'l passing ¼" 5-10 % dry wt.
Est. % of stone over 6" 8 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Small well developed feature with limited extent.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: The above quantity estimate is high and further exploration is necessary. Mat. appears suitable for any of the proposed uses.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/172

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 102 XXXXX or Canada 168-64

Location of Deposit 1 ml. North of Williamsburg, Ont.

Name of Owner

Transportation Facilities
Existing Exposure: Description of Pit Very small pit with considerable piles of material over 6" in pit.

Mat'l removed 1,000 cu. yds. Working face 3 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Mat. only a partly washed glacial till. Numerous boulders.

Shale or rotten stone Some Est.gravel/sand ratio 60/30
Gradation of SAND Fair Gradation of GRAVEL Poor
Est. % of silt of mat'l passing ¼" 5 % dry wt.
Est. % of stone over 6" 15.20 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Small Beach Description Very small beach.

Est. Quantity 2,000 cu. yds. Est. Max. Working face 3 feet

Inspector's Recommendations: Deposit so small further consideration not believed necessary.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/173
D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 103 ~~XXXX~~ or Canada

Location of Deposit $1\frac{1}{2}$ mls. north of Glen Backer, Ont.

Name of Owner

Transportation Facilities 3/4 ml. from black top Rd.
Existing Exposure: Description of Pit Very Small, bouldery pit, the expansion being limited by a larg swamp, till showing on floor of pit.

Mat'l removed 1,000 cu. yds. Working face 5 feet
Equipment in pit None
Projects furnished Local roads & form use.
Description of mat'l Mat. fairly clean and fairly well graded

Shale or rotten stone Little Est.gravel/sand ratio 40/60
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing $\frac{1}{4}$" 5 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Very small feature being thin and limited in extent

Est. Quantity 5,000 cu. yds. Est. Max. Working face 8 feet

Inspector's Recommendations: Because of limited extent further exploration is not believed necessary.

Date 2/18/42

Signed M. J. Verville

File No. S-A-2/174

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y,
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 104 XXXXX or Canada 165-62

Location of Deposit $1\frac{1}{2}$ ml. Northeast of Cardinal Ont.

Name of Owner

Transportation Facilities $\frac{1}{2}$ ml. from Canadian National R.R.
Existing Exposure: Description of Pit Small pit newly opened

Mat'l removed 2,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished Local road surfacing
Description of mat'l Mat. fairly clean, fairly well graded, but having platey gravel.

Shale or rotten stone some Est.gravel/sand ratio 35/65
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing $\frac{1}{4}$" 7-10 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed feature. Depth of deposit doubtful because of till.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: This deposit should be suitable for any proposed work in the vicinity of Cardinal.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/175

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 105 XXXXX or Canada 165-62

Location of Deposit 1 mi. northeast of Cardinal Ont.

Name of Owner

Transportation Facilities 1/4 mi. from Canadian National R.R.
Existing Exposure: Description of Pit Very small pit opened by farmer for private use.

Mat'l removed 1,000 cu. yds. Working face 6 feet
Equipment in pit None
Projects furnished Farm use
Description of mat'l Mat. quite dirty, being only a slightly washed glacial till.

Shale or rotten stone Little Est.gravel/sand ratio 35/65
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 10-12 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description long but shallow feature. Poorly developed beach.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 10 feet

Inspector's Recommendations: Mat. from this deposit appears suitable for Road or backing material, but processing would be necessary for more select uses.

Date 2/18/42

Signed M. J. Verville

File No. S-A-2/176

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Morrisburg Quadrangle

Quadrangle Morrisburg Pit 106 UXXXX or Canada 165-60

Location of Deposit 4 mls. west of Cardinal 2 mls north of C.N.R.R.

Name of Owner

Transportation Facilities 2 mls. north of C.N.R.R.
Existing Exposure: Description of Pit Fairly large pit, consisting of chiefly glacial till. Numerous large piles of boulders on floor of pit.

Mat'l removed 10,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished Local roads
Description of mat'l Mat. dirty and containing numerous cobbles over 6".

Shale or rotten stone Considerable Est.gravel/sand ratio 40/60
Gradation of SAND Fair Gradation of GRAVEL Poor
Est. % of silt of mat'l passing ¼" 10 % dry wt.
Est. % of stone over 6" 15-20 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Limited in extent and no line between till and gravel.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Mat. suitable for road fill, but appears too gravelly and dirty for any other use.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/177

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 205 XxxSx or Canada 18-4

Location of Deposit 2 mls. west of Osnabruck Centre, Ont.

Name of Owner

Transportation Facilities
Existing Exposure: Description of Pit

Mat'l removed ______ cu. yds. Working face ______ feet
Equipment in pit
Projects furnished
Description of mat'l

Shale or rotten stone ______ Est. gravel/sand ratio ______
Gradation of SAND ______ Gradation of GRAVEL ______
Est. % of silt of mat'l passing ¼" ______ % dry wt.
Est. % of stone over 6" ______ % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Short, shallow feature.

Est. Quantity 2,000 cu. yds. Est. Max. Working face ______ feet

Inspector's Recommendations: Deposit very small, being limited in extent and depth. Suitable Mat. grades into sand at bottom of deposit.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/178

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
_______________ Quadrangle

Quadrangle Winchester Pit 204 ~~U.S.~~ or Canada 18-4

Location of Deposit 2 mls. west of Osnabruck Centre, Ont.

Name of Owner ____________

Transportation Facilities Deposit located on good gravel rd.
Existing Exposure: Description of Pit Small sand pit with small amount of gravel.

Mat'l removed 5,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished ____________
Description of mat'l Mat. lacking in coarse sand and gravel. Mat. fairly uniform

Shale or rotten stone ____________ Est.gravel/sand ratio 20/80
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 5 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Bar Description Well developed feature, stratified.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 10 feet

Inspector Recommendations: Mat. appears too fine for any proposed use.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/179

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 / 4 5 6 / 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 203 ~~U. S.~~ or Canada 17-6

Location of Deposit 3 mls. north of Gallinger town Ont.

Name of Owner

Transportation Facilities 3 miles of poor dirt rds to black top
Existing Exposure: Description of Pit Very small bouldery pit
Numerous piles of boulders on floor of pit.

Mat'l removed 5,000 cu. yds. Working face 10 feet
Equipment in pit None
Projects furnished
Description of mat'l Fairly dirty, with large number of boulders.

Shale or rotten stone some Est.gravel/sand ratio 35/65
Gradation of SAND fair Gradation of GRAVEL fair
Est. % of silt of mat'l passing ¼" 10-15 % dry wt.
Est. % of stone over 6" 8-12 % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed but shallow feature.

Est. Quantity 8,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Expansion of pit limited in depth by swamp conditions. Mat. too coarse for any use but road fill.

Date 2/18/42 Signed M. J. Verville

File No. S-A-2/180

D.O. Form No. 86

St. Lawrence River Project
Massena, N. Y.
SAND & GRAVEL INVESTIGATIONS
for
Road, Filter and Backing Mat'ls
FIELD INSPECTOR'S REPORT

1	2	3
4	5	6
7	1 2 3 4 5 6 7 8 9	9

Location on U. S. Quadrangles
Winchester Quadrangle

Quadrangle Winchester Pit 201 U. S. or Canada 6-7

Location of Deposit 2 mls. East of Berwick

Name of Owner

Transportation Facilities 2½ ml. hawl on poor dirt roads to black top to Avonmore
Existing Exposure: Description of Pit Fairly large pit now abandon and over grown.

Mat'l removed 8,000 cu. yds. Working face 12 feet
Equipment in pit None
Projects furnished
Description of mat'l Mat. is lacking in coarse sand sizes and contains no gravel. Mat. very clean.

Shale or rotten stone Est.gravel/sand ratio 15/85
Gradation of SAND Gradation of GRAVEL
Est. % of silt of mat'l passing ¼" 0-2 % dry wt.
Est. % of stone over 6" - % vol.

Sampling: None

(See attached sheet for test results)

Nature of Deposit: Type Marine Beach Description Well developed Feature, but too well graded.

Est. Quantity 10,000 cu. yds. Est. Max. Working face 12 feet

Inspector's Recommendations: Gradition & lack of gravel appears to make this deposit unfavorable

Date 2/18/42

Signed M. J. Verville

File No. S-A-2/181

D.O. Form No. 86

University of
Connecticut
Libraries

39153020807063

BOUND BY
HNM